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INVESTIGATIONS CONCERNING THE TREATMENT OF AMŒBIC DYSENTERY

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and
LAMBERTO LEIVA
Of the College of Medicine and Surgery, University of the Philippines

INTRODUCTION

Amœbic dysentery is one of the more-important diseases caused by protozoa in which laboratory methods for the experimental study of its treatment have not yet been established. Many experiments, more or less isolated, have been recorded. In contradistinction to the work of Harris,(6) Vedder(16) showed that in vitro emetine is the active agent in ipecacuanha that is responsible for its toxic action on cultural amœbæ. Rogers(12) soon demonstrated, very convincingly, that emetine possesses a definite curative action in entamœbic infections in man. It seemed almost superfluous, therefore, to test the effect of emetine on lower animals. Dale and Dobell(3) in a very valuable paper and, later, Mayer(9) reported that emetine has no beneficial action in the treatment of amœbic dysentery in the cat.

Notwithstanding the striking benefit produced by emetine in amœbic infections in the majority of patients, the treatment still leaves much to be desired. The development of an appropriate laboratory method would facilitate the study of the effect of emetine or its derivatives and of other products in amœbic infections. This paper deals with: I. Experiments upon cultural

amœbæ in vitro; II. Results obtained in treating cats infected with *Entamœba histolytica;* and III. Clinical observations.

I. EXPERIMENTS UPON CULTURAL AMŒBÆ IN VITRO

Cultural amœbæ.—Considerable difficulty is encountered in testing and interpreting the effect of various agents upon amœbæ in vitro. The chief obstacle lies in the absence of any reliable method for the artificial cultivation of the pathogenic amœbæ. Indeed, it is not yet established that multiplication of the entamœbæ has been induced in vitro. Realizing these deficiencies, Vedder tested the effect of emetine on the non-pathogenic cultural amœbæ of the limax group. Bouillon diluted with water (1 to 20) was used, and the substance to be tested was added directly to this fluid culture medium before inoculation. Pyman and Wenyon(11) carried out similar experiments, using a solid agar instead of a liquid medium. These authors raise the question as to whether the drugs incorporated in the medium distribute themselves uniformly between the agar and the slight amount of fluid of synæresis on its surface.

Entamœba histolytica.—Many observers have tested, by direct microscopic examination, the effect of various substances on *E. histolytica.* This parasite, however, degenerates spontaneously, and with great rapidity, on removal from its host. The results with a given drug are often inconstant and irregular. As would be expected, the data of various workers are often divergent. Dale and Dobell report an exceptional instance in which amœbæ survived the action of emetine at 1 to 100 for a period of one hour. Rogers found that a dilution of 1 to 100,000 caused immobilization in a few minutes, the amœbæ being apparently dead.

The work here reported has been conducted entirely with a limax type of amœba. The substances tested were emetine, quinine, neosalvarsan, cholalic acid, benzyl benzoate, papaverine, *Castela nicholsoni* Hooker, *Tinospora rumphii* Boerläge, and some miscellaneous control substances. The amœba used was isolated originally from the stool of a healthy person. The stock cultures were kept on the usual agar medium using 15 grams of agar and 15 cubic centimeters of normal soda per liter of water. No attempt was made to isolate a strain of this amœba from a single cell nor to identify the mixture of bacteria growing with it. A fluid medium was prepared as follows: Peptone, 1 gram; sodium chloride, 1 gram; lactose, 1 gram; artesian water, 1,000 cubic centimeters. Varying dilutions of the agents

to be tested were prepared with this solution and, without sterilization, were immediately inoculated from a suspension of amœbæ from a twenty-four hour culture on agar. All incubations were made at 37° C. Observations were recorded at daily intervals until encystment of the amœbæ in the control cultures had occurred. A repetition of all tests was made with freshly prepared solutions. The results are recorded in Table 1.

TABLE 1.—*The inhibition of limax amœbæ in cultures by various substances.*

Substance tested.	Dilution.	Results.
Emetine hydrochloride	1-100,000	Bacteria only.
Do	1-1,000,000	Do.
Do	1-5,000,000	Occasional amœbæ.
Do	1-10,000,000	Numerous amœbæ.
Do	1-50,000,000	Do.
Quinine dihydrochloride	1-100,000	Bacteria only.
Do	1-500,000	Numerous amœbæ.
Do	1-1,000,000	Do.
Cholalic acid (from bile salt)	1-500	Bacteria only.
Do	1-1,000	Moderate number of amœbæ.
Do	1-5,000	Numerous amœbæ.
Benzyl benzoate (suspension)	1-10,000	Bacteria only.
Do	1-50,000	Do.
Do	1-100,000	Occasional amœbæ.
Do	1-500,000	Numerous amœbæ.
Do	1-1,000,000	Do.
Papaverine hydrochloride	1-5,000	Amœbæ (precipitation).
Do	1-10,000	Bacteria only.
Do	1-50,000	Numerous amœbæ.
Do	1-100,000	Do.
Neosalvarsan	1-500	Bacteria scanty.
Do	1-1,000	Bacteria only.
Do	1-5,000	Numerous amœbæ.
Castela nicholsoni	1-5,000	Bacteria only.
Do	1-5,000	Moderate number of amœbæ.
Do	1-5,000	Bacteria only.
Do	1-10,000	Numerous amœbæ.
Tinospora rumphii	1-100	Bacteria only.
Do	1-200	Numerous amœbæ.

It is impossible to compare the data in Table 1 with the results of other workers, on account of the variation in the species of amœbæ that were employed. It is clear, however, that Vedder's results are again amply confirmed.

Quinine, used as the dihydrochloride, exhibited a pronounced restraining effect on these cultures of amœbæ; of the substances tested it was second only to emetine.

In the absence of any bile salts, a specimen of cholalic acid was neutralized with sodium hydroxide. Its toxicity was rather low.

Papaverine was used as the hydrochloride, a salt which is only moderately soluble in water (about 1 to 37) and very much less soluble in physiological saline. Even the higher dilutions (1 to 5,000) prepared with this culture medium showed extensive precipitation. The results obtained were irregular, and duplicate tests showed considerable variation.

Benzyl benzoate is almost insoluble in water. Nevertheless, its suspensions in this culture medium inhibited the growth of amœbæ to a remarkable degree. Simpler benzene derivatives, ordinarily used to prevent bacterial decomposition, showed no such effect. Abundant growth of amœbæ was permitted by benzene itself in a suspension of 1 to 1,000; by toluene, at 1 to 1,000; and by xylene, at 1 to 10,000.

Tests with neosalvarsan are necessarily unsatisfactory, since solutions of this drug oxidize rapidly and increase in toxicity at room temperature. However, a dilution of 1 to 5,000 permitted free growth of amœbæ. In one of the tests a solution of neosalvarsan was shaken vigorously for fifteen minutes before diluting with the culture medium. The amœbæ grew just as well as in the corresponding dilutions that were not shaken. As would be expected, this initial increase in toxicity produced by shaking could not be detected by tests extending over a period of from one to three days.

An active principle of *Castela nicholsoni* was prepared by a method previously described.(14) This product was only slightly soluble in water. However, a dilution of 1 to 5,000 was usually sufficient to inhibit amœbæ.

Tinospora rumphii Boerläge contains an extraordinarily bitter principle. This plant is known to the Tagalogs as *makabuhay*, signifying "Giver of life." It is widely used in the Philippines. In India, there is a related species, *T. cordifolia* Miers; this name is given in the Indian Pharmocopœia, and the plant is used in the treatment of malaria and syphilis. A bitter principle of the Philippine species was prepared by A. H. Wells, in charge of the division of organic chemistry of the Bureau of Science. It possessed only an insignificant action against the cultures of this amœba.

DISCUSSION

In chemotherapeutic work in amœbic dysentery, tests of toxicity of a drug for limax amœbæ are not without value for

the purpose of obtaining general orientation. Obviously, the results cannot be applied directly to *Entamœba histolytica* any more than the effects of experiments on lower animals can be applied directly to man. It is also perfectly clear that the effects in vitro do not imply a corresponding action in the animal body.

Vedder, as the result of his work with emetine on limax amœbæ, suggested that this drug in solution in the body fluids might be capable of killing or inhibiting *Entamœba histolytica* in the tissues of the intestinal mucosa, or even in the liver. Subsequent experience has amply justified this suggestion. In contrast to this, the entirely insignificant action obtained in vitro with *Tinospora rumphii* offers no encouragement for its use in amœbic infections.

II. RESULTS OBTAINED IN TREATING CATS INFECTED WITH ENTAMŒBA HYSTOLYTICA

Literature.—The treatment of amœbic dysentery in lower animals was undertaken with the purpose of developing a dependable method for the experimental chemotherapy of this disease. The infection of laboratory animals with *Entamœba histolytica* cannot be accomplished with ease and precision. Cats are ordinarily used, and the course of the experimental disease is best understood in the cat. Adult cats are not very susceptible to infection, and in kittens the disease usually assumes a fulminating type which obviously presents enormous difficulties in experimental therapy. This is well illustrated by the experience of previous workers. Dale and Dobell became discouraged in view of their failure to modify fulminating infections in kittens by treatment with emetine. They concluded that emetine has no direct action on *Entamœba histolytica,* either in man or in kittens; its undoubted therapeutic effect in man was ascribed, not to any direct action on amœbæ, but to some occult alteration of the tissues of the host through which the tissues become more resistant to amœbæ. This alteration of the tissues was supposed to be produced by emetine in man, but not in cats.

Dale and Dobell worked exclusively with small kittens, six to eight weeks old, weighing 500 to 600 grams. Emetine failed to cure infected kittens and also failed, prophylactically, to prevent infection when administered before the injection of amœbæ. It was given hypodermically, by rectal injection, and by mouth as the double iodide with bismuth. It is much to be

regretted that the authors recorded but little detail of the actual experiments. The total number of animals in which treatment with emetine was attempted is not stated. Two strains of amœbæ were employed, one of which was exceedingly virulent, the other somewhat less so. One gathers the impression that the major portion of the work was carried out with the more virulent strain. The number of passages through which the strains had been passed before inoculating cats for treatment is not stated, the authors considering that *Entamœba histolytica* does not adapt itself to its new host with any increase of virulence on subpassage.

A detailed description is given of one typical experiment in which one kitten failed to respond to hypodermic injections of emetine. This animal and two controls were successfully inoculated with amœbæ, all of them showing an incubation period of only one day. The two controls died four days after the injection of amœbæ. In testing the effect of emetine, it is very unfortunate that treatment was deferred for one day after the diagnosis was established. The experimental kitten weighed 500 grams and received 5 milligrams of emetine hydrochloride subcutaneously. This produced vomiting and, therefore, 3 milligrams were given on the second and, again, on the third day of treatment. Death occurred on the following (or fourth) day. All three animals at autopsy showed typical ulcers in the large bowel.

Kittens were also treated by the rectal injection of 10 cubic centimeters of emetine hydrochloride in 1 to 10,000 dilution. The authors report that certain samples of *Entamœba histolytica* will withstand the action in vitro of emetine at 1 to 1,000, and even 1 to 100, for one hour, and they infected kittens with amœbæ surviving treatment by 1 to 1,000 emetine. In no case could they detect any microscopic evidence of injury to *Entamœba histolytica* by treatment for one hour with 1 to 10,000 emetine. It can hardly seem surprising, therefore, that a dilution which is without effect in vitro should also fail to produce curative results in vivo.

The failure of emetine to cure kittens infected with the less-virulent strain is recorded, but no experiments are described.

One experiment is described concerning prophylaxis with emetine. Two kittens were given 4 milligrams of emetine bismuthous iodide by mouth. (This compound contains about 30 per cent of emetine.) On the second day, these two kittens and

two controls were injected per rectum with 5 cubic centimeters of an emulsion of the more-virulent strain of amœbæ. The administration of 4 milligrams of emetine bismuthous iodide was repeated by mouth in the two kittens receiving prophylactic treatment. On the first day after the injection of amœbæ, one of the controls and one of the treated kittens were passing blood-stained mucus and amœbæ. The treatments with emetine were omitted on that day. On the second day after injection of amœbæ, the other treated kitten was positive; the remaining control continued negative throughout the experiment. On the second and third days after inoculation, 10 milligrams of the double iodide were given by mouth to the kittens under treatment and then the emetine was discontinued. The infected control died on the fourth day after injection, one of the treated kittens died on the fifth, and the other was killed on the tenth. Typical ulceration was found in all on post-mortem examination.

Mayer(9) produced amœbic dysentery in kittens and tested the therapeutic action of emetine, derivatives of emetine, simaruba, tartar emetic, papaverine, and other substances. No satisfactory results were obtained. Of sixteen cats none was cured with emetine. Emetathylin was efficacious but very toxic.

The observations of Ware(17) in India are of interest. At one of the hill stations, dysentery had given considerable trouble in a pack of foxhounds. Seven animals were affected. Smears from the fæces of the first two hounds that were examined showed amœbæ extremely like *Entamœba histolytica.* All seven were then injected with emetine, and all responded promptly. Dosages of 1 grain were used for large hounds and 0.5 grain for dogs the size of a fox terrier. Only one relapse occurred, although some were obstinate cases of several months' standing. This helpful observation from practice points very directly to the conclusion that emetine was immediately responsible for the recovery of these animals. This conclusion is questioned by Dobell(4) on the ground that the dogs might have recovered without treatment, and because he was not able to cure acute experimental infections in young kittens.

TECHNIC OF EXPERIMENTS

Several strains of amœbæ were inoculated into cats, and the infected animals were treated with various drugs. Attention was directed primarily to emetine, the standard agent for use in man. Quinine and papaverine were also tested, and prelimi-

nary experiments were carried out with benzyl benzoate and *Castela nicholsoni*. Two experiments were carried out on the prophylactic effect of emetine in kittens.

Inoculation.—Kittens are remarkably susceptible to *Entamœba histolytica,* though it is difficult to infect adult cats. In any long series of experiments many irregularities occur. A strain of *Entamœba histolytica,* when passed rapidly through kittens, often assumes fulminating characteristics. In the earlier part of this work we inoculated animals of various sizes with stools obtained direct from patients, in order to secure infections of only moderate severity for treatment. Later on, strains were sometimes carried through several passages in kittens, and from these older animals were inoculated. Specimens of dysenteric stools from patients were injected per rectum, through a small catheter, into animals under general anæsthesia. For subinoculation, the kittens were sacrificed at the height of the infection. The lower third of the large bowel was usually uniformly involved and free from gross fæcal matter. The œdematous and hæmorrhagic mucosa was scraped off with a scalpel and covered with salt solution. These gross particles were rich in amœbæ; without breaking them up unnecessarily, they were injected per rectum, under general anæsthesia, into older cats to be used for treatment and into kittens for maintaining the strain.

Diagnosis.—For the treatment of acute experimental dysentery in cats, the first essential is an early diagnosis. It is useless to delay until spontaneous discharge of blood, mucus, and amœbæ has set in. After a few passages of a strain in animals, the incubation period becomes remarkably short. By employing large saline enemata, amœbæ can often be recovered from the injected animals one or two days before spontaneous symptoms appear, and before extensive destructive lesions of the bowel have developed. Even in the larger cats, a diagnosis was sometimes established forty-eight hours after injection. This does not in any sense suggest that one is merely recovering the amœbæ originally inoculated or that mere multiplication is taking place without the production of lesions. In the first place, some of these larger animals, showing amœbæ on the second day, had been examined and found negative on the first day after injection. Furthermore, we have sacrificed and examined two of these older animals. In one, forty-eight hours after injection, the saline enema which was returned showed a minute fleck of blood containing a few active amœbæ. On the post-mortem examination of the intestine, one hæmorrhagic

area, 3 millimeters in its longest diameter, was found in the lower third of the larger bowel; amœbæ were plentiful in this lesion. In another cat, a diagnosis was obtained three days after injection; post-mortem examination at this time showed one superficial ulcer, 5 millimeters in diameter, in the lower third of the large bowel. In the earlier part of the work little attention was given to specimens that failed to show gross amounts of mucus or blood, and in some of these animals incubation periods as long as five days have been recorded. Subsequently, the specimens were examined carefully for even minute flecks of blood or mucus, and earlier diagnoses were obtained. The routine was eventually established of giving saline enemata daily for diagnosis, commencing the second day after the injection of amœbæ.

Treatment.—A few preliminary trials were made in the treatment of infected cats by the subcutaneous injection of emetine. It was not well tolerated and showed little or no effect on the amœbæ. Subsequently, emetine and the other drugs tested were given in moderately strong solution by rectal injection. On account of the tendency to expel these therapeutic enemata, the animals were always held head downward for a half hour after injection. Examinations for amœbæ were continued daily during the early period of treatment.

Controls.—Spontaneous recovery has been occasionally noted in adult cats; it is of rare occurrence. In this work we have not depended in any sense upon the uncertainties of statistical evidence, but rather upon observation of the immediate radical effect of therapy analogous to the establishment of the therapeutic effect of emetine on amœbic infections in man. From time to time, however, we have arranged for control animals to determine the severity of the various strains of amœbæ used in this work.

Emetine.—Emetine is distinctly toxic for cats. Moreover, repetitions of the effective therapeutic dose are tolerated only for short periods. In our experiments it at once became necessary to establish the maximum limits of the tolerated dosage. This was tested chiefly by injections per rectum. Given in this manner, quantities of 10 milligrams per kilogram of body weight caused no loss of appetite, whereas this amount injected subcutaneously produced nausea and vomiting almost constantly. Moreover, a distinctly better therapeutic effect was obtained by rectal injection as compared with parenteral administration.

The results on normal cats showed that the rectal injection of 10 milligrams per kilogram of body weight for three successive days approaches the danger limit. Except in a few instances, the total quantity of emetine used in treatment has not exceeded 25 milligrams per kilogram of body weight.

Subcutaneous and rectal treatment.—A preliminary test of treatment with emetine was made on an adult cat (No. 1) which developed an acute dysentery after inoculation with a patient's stool. A subcutaneous injection of emetine (8 milligrams per kilogram of body weight), sufficient to cause slight vomiting, produced no discernible effect on the amœbæ. On the second day, 4 milligrams per kilogram were given subcutaneously. On the third day of treatment, rectal injections of emetine were commenced, and three days later the amœbæ disappeared. A little later normal, formed stools were passed. Treatment was discontinued, and the animal remained in apparent health, only to relapse. Treatment was not resumed. Death occurred twenty-seven days after injection of amœbæ. The autopsy showed typical ulceration of the large bowel and two amœbic abscesses of the liver.

There is a twofold difficulty in the treatment of kittens; (*a*) being very susceptible to amœbic infection, they require maximal doses of emetine; and (*b*) the rapid development of lesions in the bowel facilitates greatly the secondary invasion by bacteria. Untreated animals frequently die a few days after inoculation; blood cultures taken during life have showed staphylococci, streptococci, *Bacillus pyocyaneus*, other unidentified bacilli, and in one instance a streptothrix. Early treatment with emetine does not protect against this bacterial invasion. Consequently, the situation arose that kittens frequently became free of amœbæ under vigorous emetine treatment, only to die in a few days, the blood culture showing a septicæmia. Even though this septicæmia is of itself an adequate cause of death, distinct care must be exercised to avoid a dosage of emetine which of itself might prove fatal. Even under these disadvantages, there was frequently sufficient time before death for testing the therapeutic action of emetine.

One animal (No. 2), weighing 870 grams, responded promptly to treatment, the stools being negative for blood and amœbæ after the first day of treatment. Emetine was discontinued three days later, after a total of 35 milligrams per kilogram of body weight had been given. This is a larger quantity than we have usually employed, but it was tolerated without nausea or loss

of appetite. This kitten became very ill eighteen days after injection of amœbæ and was sacrificed. The large intestine showed no microscopic lesions, and no amœbæ were found in smear preparations. A blood culture developed a growth of staphylococcus. A similar result was obtained in the case of kitten 16. Two other kittens (Nos. 10 and 13) behaved in a very similar manner, except that the bacterial complications were more acute, and the animals were sacrificed in little more than a week after injection. No amœbæ were found at autopsy. It is entirely possible that a recrudescence of the amœbic infection might have developed in these animals; but, even if this beneficial result is only temporary, it constitutes a striking contrast to the continuous excretion of amœbæ by the untreated kittens.

The best results were obtained by securing an early diagnosis in adult cats, giving the treatment by rectum. Two adults (Nos. 17 and 18) showed considerable blood and numerous amœbæ on the third day after injection. Emetine in 1 to 1,000 solution was given in a dose of 7.5 milligrams per kilogram to one of these animals and 10 milligrams per kilogram to the other. On the next day, a large normal saline enema was given, but no blood nor amœbæ were obtained from either animal. Treatment was continued until one cat had received a total of 22.5 milligrams of emetine per kilogram of body weight and the other 20. These animals remained well for a long period. One eventually died, thirty-five days after injection. The autopsy did not show any obvious cause of death. The large bowel was entirely free from lesions. The other died eighty-two days after injection. The autopsy showed an extensive bronchopneumonia; the large bowel was free from lesions. These two cats were inoculated from a kitten (No. 20) which developed extensive dysenteric lesions after having received a prophylactic injection of emetine. The virulence of the strain, however, was shown by the acuteness of the initial symptoms in the two treated animals and in an adult control (No. 19), which died six days after inoculation and showed typical amœbic ulceration of the bowel.

The radical cure of amœbic infection in cats is strongly indicated by this experiment. However, adults do not always escape bacterial complications, even though the amœbæ are promptly inhibited by emetine treatment. This was seen in three instances (Nos. 3, 4, and 12).

Inadequate treatment.—In two kittens (Nos. 8 and 9) treatment was discontinued before the maximum tolerated dose had been given. In one (No. 8), after the reappearance of symptoms, a liberal injection of emetine was entirely unavailing; in the other, small doses of emetine were given from the beginning. The symptoms subsided temporarily and then returned while the animal was under treatment.

Delayed treatment.—Some of the animals responded so promptly to emetine that it seemed worth while to try the effect of delaying treatment for a day after the diagnosis was established. In one instance a kitten (No. 7), weighing 800 grams, was passing blood rich in amœbæ four days after inoculation with a patient's stool. On the next day treatment was commenced, giving 10 milligrams of emetine per kilogram of body weight by rectal injection. On the following day frequent bloody stools were passed, rich in actively motile amœbæ. Emetine (10 milligrams per kilogram) was repeated. On the next day the kitten was found dead. Autopsy showed extensive lesions of the bowel, and many amœbæ were still slightly motile.

Effective and tolerated doses.—All of this experimental work has indicated that there is only a small margin between the effective and the tolerated doses of emetine, even under favorable conditions of commencing treatment early in the disease. In adult cats the amœbic infection was sometimes controlled by a dose of about two-thirds the tolerated amount (Nos. 17 and 18). This favorable result, we assume, is due to the natural resistance of adults to *Entamœba histolytica*. In the more-susceptible kittens, the margin between the effective and the tolerated dosage was sometimes very small indeed.

Prophylaxis.—The extreme susceptibility of kittens to *E. histolytica* is strikingly illustrated by their successful infection even when receiving preliminary treatment with emetine. Three kittens, receiving 5 to 10 milligrams of emetine per kilogram of body weight subcutaneously, were inoculated a half hour later with amœbæ. All became infected, the incubation period varying from one to five days. In a second experiment, two kittens were infected after receiving similar doses of emetine per rectum, both showing a decidedly long period of incubation. In these preliminary tests, the use of emetine by rectum gave promise of affording better results than did the subcutaneous

injection. These two experiments do not exhaust the possibilities of preventing dysentery in kittens by the prophylactic use of emetine.

Quinine.—For the most part indifferent or poor results have been reported in the treatment of amœbic dysentery by quinine, although this drug is toxic for cultural amœbæ in vitro and produces very definite effects therapeutically in malaria. A few years ago Brooke(1) reported rather favorable results in the treatment of chronic amœbic infections in man.

Our first test of quinine on animals was made with a cat (No. 27), which for two days had failed to show any response to papaverine. Under large doses of quinine dihydrochloride (200 milligrams per kilogram in 1 to 50 solution) the symptoms improved promptly, and the amœbæ for a short time became very scarce, though it was not possible to eradicate the infection. This temporary improvement under quinine of a well-established infection is in marked contrast to the failure of emetine under similar conditions. A second animal (No. 29) was treated by rectal injection with quinine in 1 to 100 dilution, immediately after the diagnosis was established. On the next day there was little change; another injection of quinine was given (200 milligrams per kilogram of body weight), increasing the concentration to 1 to 50. After a half hour some mucus was expelled which was free from amœbæ. On the next day the stools were negative. Quinine was given once more (200 milligrams per kilogram) and then discontinued. The animal remained in good health for many days, and the stools were formed and negative for blood and amœbæ. Then a relapse occurred. No further treatment was given, and death took place thirty-one days after the inoculation with amœbæ. A third cat (No. 30) was treated more intensively. After an incubation period of three days, this animal was passing blood-streaked mucus rich in amœbæ. Injections of quinine (200 milligrams per kilogram of body weight in 1 to 50 dilution) were commenced at once and continued daily. On the day after the first treatment, the stool showed a trace of tarry blood, and one amœba was found. Thereafter the specimens were negative for blood and amœbæ. On the seventh day of treatment this cat, though strong and active, showed slight muscular tremors and a little nystagmus. Quinine was therefore discontinued. This animal has remained free from symptoms, and no amœbæ have subsequently been found; the last observation was made forty days after inoculation.

Papaverine.—The use of papaverine in protozoan infections has been suggested from time to time, on account of the occurrence of chemical groupings in this alkaloid similar to those in emetine. Pick and Wasicky(10) noted that quinine, emetine, and papaverine were decidedly toxic for cultural amœbæ; emetine, however, was slightly weaker than the other two. Macht and Fisher(8) ascribe the toxic action of papaverine on paramœcia to the benzyl grouping.

Two animals were treated with papaverine by rectal injection in relatively large dosage. Nothing more than a very transient restraining effect on the amœbæ was observed. The first cat received 50 milligrams per kilogram of body weight; on the next day a saline enema was returned which showed one blood clot and many degenerating cells resembling amœbæ; one nonmotile amœba was found. The same dosage of papaverine was repeated. On the following day this cat was passing blood frequently. Numerous active amœbæ were present and treatment with quinine was started. The second cat treated with papaverine received 50 milligrams per kilogram of body weight. On the following day no amœbæ were seen; 75 milligrams of papaverine per kilogram were given. On the next day a few amœbæ were present, and death occurred during the night. At autopsy, typical lesions were found, and sections of the bowel showed definite amœbæ.

Benzyl benzoate.—Macht(7) reported favorable specific action of this drug in several cases of amœbic dysentery. The details of one case were given, but the record is without value. No microscopic examination of the stools was noted either before or after treatment, the opinion being based upon the patient's statement concerning the number of stools. We have had an opportunity to test the action of benzyl benzoate in only one animal. Two days after injection with amœbæ, a saline enema was returned with copious amounts of blood and numerous amœbæ. A suspension of benzyl benzoate (0.5 cubic centimeter per kilogram) in normal saline was injected per rectum. A little was expelled a half hour later and no living amœbæ were found. The next day the cat was passing blood freely, and the amœbæ were very numerous and active. The same dosage was repeated. Death occurred during the night. Although this infection was evidently a rather severe one for treatment, it is significant that benzyl benzoate failed to show any restraining influence.

Castela nicholsoni.—A few preliminary tests were made with *Castela nicholsoni* (chaparro amargoso), but no satisfactory results were obtained. The preparation that was employed is described later in connection with the treatment of dysentery in man. It was extremely toxic for cats, 1 cubic centimeter per kilogram, per rectum, proving fatal. Dosages that showed some therapeutic effect were not tolerated well. If successful results are to be obtained in treating cats with *Castela nicholsoni,* considerable experimentation will be required to determine the most favorable mode of its employment.

The general results of these experiments are summarized briefly in Table 2.

DISCUSSION

In these investigations on the treatment of experimental amœbiasis, quinine was found to possess one distinct advantage over emetine, in that animals would tolerate the continued repetition of effective therapeutic doses. However, it is obviously unsound to draw any final conclusions from limited experience with one or two strains of amœbæ.

From a clinical standpoint it is seen that the amount of quinine necessary to control amœbic infection in cats is very large. One animal (No. 29) eventually relapsed after receiving about 500 milligrams per kilogram of body weight. The minimal effective dose of quinine was not determined. Neither have we tested the effect of quinine administered by mouth or by parenteral injection.

In the treatment of patients with quinine, very dilute solutions (1 to 5,000) are ordinarily recommended, the concentration being increased later to 1 to 1,000 or 1 to 500. We are not aware of any evidence that this preliminary injection of dilute solutions decreases the susceptibility of the bowel for the more-concentrated injections. It is conceivable that the preliminary treatment results chiefly in the loss of time and that, if quinine is to be used, treatment might well be commenced with stronger solutions.

Throughout these experiments we have depended upon the administration of emetine by rectum in rather strong solution. Subcutaneous injection was discontinued on account of the very unfavorable preliminary test. In those special patients in whom emetine by intramuscular injection produces no response, it would seem to us that rectal injection might be worthy of consideration. Obviously, this mode of administration has not met with favor as a routine procedure. Moreover, the simple,

TABLE 2.—*Treatment of experimental amœbic dysentery.*

EMETINE HYDROCHLORIDE.

Cat No.	Weight	Incubation period.	Dosage per kilogram of body weight.	Behavior under treatment.
	g.	*Days.*	*mg.*	
1	2,200	6	28	Partial response. Death twenty-seven days after inoculation.
([a])	1,000	3	--------	Death six days after inoculation. Extensive lesions.
([a])	1,450	4	--------	Death seven days after inoculation. Extensive lesions.
2	870	6	35	Negative for amœbæ. Septicæmia. Sacrificed eighteen days after inoculation.
3	1,830	5	30	Partial response. Death (pneumonia) nine days after inoculation.
4	1,500	5	30	Negative for amœbæ. Septicæmia. Sacrificed nine days after inoculation.
5	1,850	5	--------	Control (Nos. 3 and 4) abundant amœbæ. Death six days after inoculation.
6	1,740	6	--------	Control (Nos. 3 and 4) abundant amœbæ. Death nine days after inoculation.
7	800	4	20	Delayed treatment. No response. Death seven days after inoculation.
8	740	4	30	Partial response. Death ten days after inoculation.
9	520	4	15	Partial response. Death (pneumonia) nine days after inoculation.
10	770	4	20	Negative for amœbæ. Septicæmia, no pneumonia. Sacrificed nine days after inoculation.
11	680	5	--------	Control (Nos. 8, 9, 10) abundant amœbæ. Death thirteen days after inoculation.
12	2,400	2	25-30	Negative for amœbæ. Pneumonia. Sacrificed eight days after inoculation.
13	650	3	25	Do.
14	1,820	3	--------	Control (Nos. 12 and 13). Death eighteen days after inoculation. Extensive amœbic ulceration.
15	1,940	4	--------	Control (Nos. 12 and 13). Death seven days after inoculation. Amœbic ulceration of bowel.
16	970	3	22.5	Negative for amœbæ. Septicæmia. Sacrificed eleven days after inoculation.
17	2,520	3	22.5	Negative for amœbæ. Death eighty-two days after inoculation.
18	2,070	3	20	Negative for amœbæ. Death thirty-five days after inoculation.
19	1,700	3	--------	Control (Nos. 16, 17, and 18). Death six days after inoculation.
				PAPAVERINE HYDROCHLORIDE.
27	1,800	3	100	Amœbæ present. Changed to quinine treatment.
28	1,220	10	125	Amœbæ present. Death thirteen days after inoculation.
				QUININE DIHYDROCHLORIDE.
29	1,440	10	[b]500	Negative for amœbæ, then relapsed. Death thirty-one days after inoculation.
30	1,360	3	[b]1,200	Negative for amœbæ. Remained well.
				BENZYL BENZOATE.
31	1,570	2	([c])	Amœbæ abundant. Death four days after inoculation.
32	1,680	3	--------	Control. Amœbic ulceration. Death five days after inoculation.

[a] Control. [b] Partial loss. [c] 1 cubic centimeter.

straight, large bowel of the cat permits local treatment more readily than in the case of man.

Occasionally the intravenous injection of emetine is recommended. This route permits the maximal toxic action of emetine on the patient and would seem to us to be the poorest mode of administration. For the treatment of abscess of the liver without operation, the theoretical possibility suggests itself that a very slightly greater concentration of emetine might be obtained in the liver by rectal rather than by intramuscular or intravenous injection, with perhaps a little less of the general toxic manifestation.

The beneficial effect of emetine on amœbic dysentery in cats provides an experimental method for studying the strains of amœbæ from patients who fail to respond to emetine therapy. These patients may, theoretically, be infected with some emetine-resistant strain of amœbæ, or the failures may be due to the vague condition of lowered resistance of the patient. The distinction between these two possibilities has not been approached experimentally; indeed, the solution of the question may lie in some simpler explanation.

COMPARISON OF EMETINE TREATMENT OF AMŒBIC DYSENTERY IN MAN AND IN EXPERIMENTALLY INFECTED ANIMALS

The interpretation of the therapeutic action of emetine in amœbic dysentery in cats necessitates some detailed study. The complete picture requires consideration, not only of the protozoölogical and pharmacological features, but also of the pathology of the experimental disease and its bacteriology, as well as an accurate knowledge of the clinical behavior of patients under treatment. The details of the pathology of the disease appear to us to be worthy of discussion. In young kittens the disease commences in the lowermost portion of the large bowel, producing an intense diffuse inflammation without any trace of normal mucosa in the infected area. In some kittens, sacrificed one day after injection, it appeared that the process begins diffusely, and not as discrete ulcers. In man, in neglected cases coming to autopsy, it is characteristic that large islands of normal mucosa are found in the affected areas. In older cats, the process approximates much more closely the conditions found in man. In two animals, which we have already mentioned, the infection started with a discrete lesion instead of a diffuse generalized inflammation. In cats, as contrasted with kittens, the disease begins less abruptly, runs a slower course,

and there is usually more opportunity for treatment with emetine before a fatal bacterial invasion terminates the experiment.

The clinical behavior of patients under emetine treatment is by no means uniform. Occasionally the symptoms and the amœbæ persist under emetine therapy in cases of only ordinary severity. Shepheard and Lillie(15) studied eighty cases of *Entamœba histolytica* carriers which failed to respond to treatment with emetine bismuthous iodide. Extremely acute infections have been described in which emetine was without value. Although it has not been demonstrated, it seems probable that bacterial invasion might occasionally be an important factor in these acute cases.

Notwithstanding the marked differences between experimental infection and the spontaneous disease, it seems to us that the action of emetine on amœbic dysentery in cats reproduces with very reasonable faithfulness the effects seen in man. Moderately severe infections in adult cats were eradicated by the early and vigorous use of emetine. Inadequate dosage or delay in treatment gave imperfect results or ended fatally, just as we have seen happen altogether too frequently in the practice of medicine in the Tropics. Indeed, it is useless to trifle with minimal dosages of emetine. The absence of any beneficial effect in the treatment of well-established hyperacute experimental infections is closely paralleled by the behavior of fulminating cases in man. Our experimental evidence does not agree with the statement that emetine is specific for *Entamœba histolytica* only in certain special hosts.(5)

The production of dysentery in kittens receiving prophylactic dosages of emetine seems a little surprising at first glance; the conditions, however, are highly artificial. These strains had been well adapted to their new host by several rapid subpassages. Animals at an extremely susceptible age were selected for the test. Moreover, the quantity of the amœbic material injected was enormous, corresponding in Dale and Dobell's work to 600 cubic centimeters for a man of 60 kilograms. Furthermore, actively multiplying tissue-invading forms were injected directly into the rectum, in contrast to the ordinary spontaneous infection with the encysted stage introduced by mouth. In our own work the prophylactic use of emetine per rectum resulted in a marked prolongation of the period of incubation. Curiously enough, this partial failure in the prophylactic action of emetine is offset in a measure by the beneficial

action which it exhibited in several instances when administered therapeutically to infected kittens.

These experiments furnish no direct evidence concerning the mechanism of the action of emetine in amœbic dysentery. In the recovery of patients, we must consider both the resistance of the host to amœbæ and the effect of emetine. Clinical evidence is very convincing that the normal individual exhibits considerable natural resistance to *Entamœba histolytica,* leading ordinarily to spontaneous remission of symptoms even in untreated patients. Emetine is not only moderately toxic for amœbæ in vitro, but is also distinctly toxic for mammals. It does not seem likely to us that *E. histolytica* in its host can entirely escape this toxic action. The maximal therapeutic doses of emetine are relatively small, but they are cumulative in their effect. Until there is experimental evidence to the contrary, we prefer to adhere to the following working basis: That recovery from amœbic dysentery in man and in lower animals results from the combined action of the natural resistance of the host and a moderate action of emetine on the amœbæ. The summation of these two factors is necessary for radical cure. A lowering of either allows the disease to progress. Minimal doses of emetine do not modify the course of the infection. The effect of feeble natural resistance of the host is beautifully illustrated by the fulminating infections seen in young kittens.

A comparison of the effective dosage of emetine in man and in experimental animals is difficult, on account of the severity of the artificial infection. Moreover, patients are treated by small doses over a period of many days or weeks, whereas the animals must be treated intensively for a short period. The following outline (Table 3) shows the relation between the ordinary therapeutic dose used in man and the quantities that we have employed. These have been arranged to show both the initial dose required to check the symptoms and the total quantity for eradicating an infection. The latter is extremely variable in man, and the figures given represent optimal results.

TABLE 3.—*Showing the amounts of emetine hydrochloride used in the treatment of amœbic dysentery in man and in cats; milligrams per kilogram of body weight.*

	In man.	In cats.
	mg.	*mg.*
Initial dose	2-4	7-10
Total quantity	18-30	20-30

These figures are of only general interest. In the first place, emetine hydrochloride was given to the infected animals by injection per rectum, whereas this alkaloid is usually given intramuscularly in man. The figures for patients are based, for convenience, on an average body weight of 60 kilograms. The initial dose in man of 2 milligrams per kilogram (that is, 2 grains) on the first day of treatment is slightly larger than the routine usually recommended. However, it is the quantity that we ordinarily employ; but, even with this amount, the symptoms are not checked as promptly as with the 10-milligram dose used in animals. The maximal initial dose in man, 4 milligrams per kilogram, represents the dosage occasionally used by Rogers(13) in severe cases; that is, 4 grains on the first day of treatment. It has not come into general use, even in especially severe cases. The figure of 18 milligrams per kilogram for the total quantity in man for the first course of treatment is taken from Wenyon and O'Connor's(18) recommendation of 1.5 grains of emetine hydrochloride for twelve consecutive days.

SUMMARY

1. The treatment of amœbic dysentery in kittens is seriously complicated by the acuteness of the amœbic process and by the secondary bacterial invasion. The disease in young kittens is not strictly comparable to amœbic dysentery in man, on account of the differences in pathology of the two conditions.

2. Suitable conditions for experimental therapy can be secured by infecting adult cats with a moderately virulent strain of *Entamœba histolytica*. In order to secure successful results an early diagnosis is imperative, and vigorous treatment must be instituted without delay.

3. Infections with *E. histolytica* were produced in cats and treated successfully with emetine and with quinine. Papaverine was inefficacious. Emetine and papaverine have certain active chemical groupings in common; namely, the four methoxy radicals. Quinine has one methoxy radical; its general structure is unlike papaverine and, presumably, unlike emetine.

4. In the treatment of cats with quinine very large doses were required; but, in contrast to emetine, repetitions of the therapeutic dose could be tolerated for many days.

5. Experimental amœbic dysentery is a somewhat artificial condition; nevertheless, it responds to emetine in a manner similar to the action of emetine in spontaneous dysentery in man.

ABSTRACT OF EXPERIMENTS

The accompanying notes give brief abstracts of the more-important experiments. Many unfavorable results have been included to illustrate the conditions essential for success. The drugs used for treatment have always been given by rectal injection, except where otherwise noted. The enemata that are recorded refer exclusively to saline injections given for the purpose of diagnosis. The microscopic examination of stools refers only to perfectly fresh specimens that were passed while the animals were under observation in the laboratory. Negative examinations for amœbæ are not recorded in the autopsy of animals that were found dead; such reports might be misleading, on account of the rapid degeneration of amœbæ after death of the host. No blood cultures were made on animals that were found dead.

TREATMENT WITH EMETINE

Toxicity.—Emetine hydrochloride was used in 1 to 1,000 dilution in water. The following tests were made to determine its toxicity. Six adult cats weighing 1,800 to 2,400 grams were given daily doses of 10 milligrams per kilogram for three successive days. The injections were made subcutaneously in two, and by rectum in the other four, the animals being observed for two to three hours after injection to be sure that no loss took place during this period. On the fourth day both of the cats receiving subcutaneous injection were found dead. Of the animals receiving injections per rectum, one was nauseated on the fourth day and died during the night; the other three remained well.

STRAIN I; FIRST PASSAGE; CAT 1

October 28, 1920. Weight, 2,200 grams; injected with amœbæ direct from patient.

November 3. Weight, 2,100 grams; enema, copious amount of blood and numerous amœbæ; incubation period six days; injected subcutaneously with 8 milligrams of emetine per kilogram; slight vomiting; during the day three bloody stools rich in amœbæ were passed.

November 4. Weight, 2,000 grams; enema, blood and active *E. hystolytica;* emetine, 4 milligrams per kilogram injected subcutaneously.

November 5. Weight, 2,000 grams; passing blood rich in amœbæ not actively phagocytic; emetine, 8 milligrams per kilogram per rectum.

November 6. Weight, 1,940 grams; yellow fæcal stool rich in amœbæ; emetine, 4 milligrams per kilogram per rectum.

November 7. No examination.

November 8. Weight, 1,790 grams; semiformed stool slightly blood-streaked; no amœbæ; enema, no blood nor amœbæ; emetine, 4 milligrams per kilogram per rectum.

November 9. No stools.

November 11. Enema, negative.

November 12. Nauseated, refuses food; suppression of urine; 200 cubic centimeters of normal saline injected intraperitoneally.

November 12. Weight, 1,900 grams; appetite good; voids freely; enema, negative.

November 18. Weight, 1,950 grams; formed stool shows no blood nor amœbæ.

November 20. Weight, 1,850 grams; freshly passed stool is negative.

November 24. Found dead; several active ulcers in the intestine and two amœbic abscesses in the liver; total emetine, 28 milligrams per kilogram within five days.

Of two control animals one, weighing 1,000 grams, showed an incubation period of three days and died on the sixth day after injection of amœbæ; the other, weighing 1,450 grams, had an incubation period of four days and died three days later.

In the next experiment one kitten and five adult cats were injected with a patient's stool, rich in blood and mucus and containing numerous active amœbæ. None of the adults became infected.

STRAIN II; FIRST PASSAGE; CAT 2

August 31, 1921. Weight, 870 grams; inoculated direct from patient.

September 6. Enema, abundant blood, mucus, and amœbæ; incubation period six days; emetine, 10 cubic centimeters per kilogram; an hour later a small bloody specimen was passed showing a few motile amœbæ and many degenerated forms.

September 7. Weight, 820 grams; enema, no blood, mucus, nor amœbæ; emetine, 10 milligrams per kilogram; two hours later a fæcal stool was passed; microscopically red blood cells were seen but no amœbæ.

September 8. Weight, 870 grams; two soft fæcal stools in cage; enema, negative; emetine, 5 milligrams per kilogram intramuscularly.

September 9. Emetine, 10 milligrams per kilogram.

September 10. Weight, 850 grams; enema, formed stool, negative; emetine discontinued.

September 12. Fresh stool is negative.

September 13. Weight, 770 grams; no stools passed.

September 15. Soft fæcal stool negative for amœbæ.

September 18. Weight, 620 grams; extensive infection about the eyes; very ill; sacrificed; large bowel shows no blood nor mucus; the mucosa shows no scars of healed lesions and microscopically no amœbæ; a culture from the heart blood showed a growth of staphylococcus; total emetine, 35 milligrams per kilogram within three days.

In the following experiment, four adult cats (Nos. 3, 4, 5, and 6) were injected with amœbæ; two were treated, bacterial complications developing very early, and two were reserved for controls.

STRAIN III; FIRST PASSAGE; CAT 3

September 28, 1921. Weight, 1,830 grams; injected direct from patient.

October 3. Enema, copious amount of blood rich in amœbæ; incubation period, five days; emetine, 10 milligrams per kilogram.

October 4. Weight, 1,800 grams; stool of tarry consistency; no fresh blood and no amœbæ; emetine, 10 milligrams per kilogram.

October 5. Weight, 1,720 grams; tarry stool shows no amœbæ; emetine, 10 milligrams per kilogram.

October 6. Enema, some blood and after long search one amœba was found.

October 7. Found dead; broncho-pneumonia; no inflammation nor ulceration of the large bowel; total emetine, 30 milligrams per kilogram within two days.

STRAIN III; FIRST PASSAGE; CAT 4

September 28, 1921. Weight, 1,500 grams; injected direct from patient.

October 3. Enema, fresh blood showing many active amœbæ; incubation period, five days; emetine, 10 milligrams per kilogram.

October 4. Soft fæcal stool, no amœbæ; enema, no blood nor amœbæ; emetine, 10 milligrams per kilogram.

October 5. Weight, 1,400 grams; emetine, 10 milligrams per kilogram.

October 6. Enema, no blood nor amœbæ.

October 7. Very ill; sacrificed; no pneumonia; one ulcer, 7 millimeters in diameter, in lower third of large bowel; no amœbæ found; blood culture showed a staphylococcus; total emetine, 30 milligrams per kilogram within two days.

STRAIN III; FIRST PASSAGE; CAT 5

Control for Nos. 3 and 4.

September 28, 1921. Weight, 1,850 grams; injected with amœbæ.

October 3. Positive for amœbæ; incubation period, five days.

October 4. Dead; typical ulceration of intestine.

STRAIN III; FIRST PASSAGE; CAT 6

Control for Nos. 3 and 4.

September 28, 1921. Weight, 1,740 grams; injected with amœbæ.

October 4. Passing mucus containing a few amœbæ; incubation period, six days.

October 7. Dead; typical ulceration of intestine.

STRAIN III; FIRST PASSAGE; CAT 7

Delayed treatment.

September 11, 1921. Weight, 800 grams; injected with amœbæ.

September 15. Passing blood rich in amœbæ; incubation period, four days; no treatment.

September 16. Bloody stools rich in amœbæ; emetine, 10 milligrams per kilogram; forty-five minutes later a stool was passed containing many degenerating amœbæ.

September 17. Frequent bloody stools, numerous active amœbæ; emetine, 10 milligrams per kilogram.

September 18. Found dead; extensive typical lesions of the lower third of the large bowel; amœbæ still motile; total emetine, 20 milligrams per kilogram within one day.

In the next experiment, four kittens were inoculated. All became infected and three were treated.

STRAIN IV; FIRST PASSAGE; CAT 8

September 24, 1921. Weight, 740 grams; injected direct from patient.

September 28. Enema, considerable blood and many amœbæ; incubation period, four days; emetine, 10 milligrams per kilogram; after ten minutes a few drops of fluid were expelled; this was rich in motile amœbæ, but they became rounded up and many degenerated while under observation during the next fifteen minutes.

September 29. Weight, 720 grams; passing blood containing amœbæ; emetine, 10 milligrams per kilogram.

September 30. Weight, 750 grams; formed stool, negative; enema, negative; no treatment.

October 1. Enema, negative.

October 3. Passing a little blood rich in amœbæ; emetine, 10 milligrams per kilogram.

October 4. Dead; intense inflammation of the lower portion of the large bowel; total emetine, 30 milligrams per kilogram within five days.

STRAIN IV; FIRST PASSAGE; CAT 9

September 24, 1921. Weight, 520 grams; injected direct from patient.

September 28. Enema, copious amount of blood and many amœbæ; incubation period, four days; emetine, 5 milligrams per kilogram.

September 29. Soft yellow stool showed no amœbæ and no gross blood; emetine, 5 milligrams per kilogram.

September 30. On starting to introduce the rectal tube, a well-formed stool was passed; no blood nor amœbæ; enema was returned with one small fleck of blood containing a few amœbæ; emetine, 5 milligrams per kilogram.

October 1. Enema, blood and amœbæ.

October 2. Enema, blood and amœbæ.

October 3. Found dead; extensive broncho-pneumonia on the left side; slight inflammation and a few minute ulcers in the lower portions of the bowel; total emetine, 15 milligrams per kilogram within two days.

STRAIN IV; FIRST PASSAGE; CAT 10

September 24, 1921. Weight, 770 grams; inoculated direct from patient.

September 28. Enema, abundant blood, mucus, and amœbæ; incubation period, four days; emetine, 10 milligrams per kilogram.

September 29. Soft fæcal stool, negative for blood and amœbæ; emetine, 5 milligrams per kilogram.

September 30. Weight, 720 grams; enema, negative; emetine, 5 milligrams per kilogram.

October 1. Enema, negative.

October 3. Sacrificed; no pneumonia; some pus in large bowel but no amœbæ found; blood culture gave a growth of streptococcus; total emetine, 20 milligrams per kilogram within two days.

STRAIN IV; FIRST PASSAGE; CAT 11

Control for Nos. 8, 9, and 10.

September 24, 1921. Weight, 680 grams; injected with amœbæ.

September 29. Abundant blood and amœbæ; incubation period, five days.

October 7. Dead; no pneumonia; extensive lesions throughout the large bowel; amœbæ present but not motile.

Of seven animals inoculated with Strain V in the second passage, four became infected (Nos. 12 to 15).

STRAIN V; SECOND PASSAGE; CAT 12

November 13, 1921. Weight, 2,400 grams; injected with amœbæ.

November 15. Enema, trace of blood and several active amœbæ; incubation period, two days; emetine, 10 milligrams per kilogram.

November 16. Weight, 2,350 grams; enema, no gross blood; microscopically, a few red cells, no amœbæ; emetine, 10 milligrams per kilogram.

November 17. Weight, 2,320 grams; tarry stool; no amœbæ; emetine, 5 milligrams per kilogram, expelled almost immediately; 2.5 milligrams per kilogram repeated subcutaneously.

November 18. Weight, 2,250 grams; enema, negative; emetine, 5 milligrams per kilogram returned at once.

November 19. Weight, 2,270 grams; enema, negative.

November 20. Weight, 2,150 grams; enema, negative.

November 21. Ill; sacrificed; extensive broncho-penumonia on right side; no inflammation of bowel, no amœbæ found; total emetine, probably 25 to 30 milligrams per kilogram within three days.

STRAIN V; SECOND PASSAGE; CAT 13

November 13, 1921. Weight, 650 grams; injected with amœbæ.

November 15. Enema, negative.

November 16. Enema, abundant mucus and many active amœbæ; incubation period, three days; emetine, 10 milligrams per kilogram; considerable loss after fifteen minutes; 2.5 milligrams per kilogram repeated subcutaneously.

November 17. Enema, negative; emetine, 2.5 milligrams per kilogram subcutaneously.

November 18. Weight, 570 grams; small bloody stool rich in amœbæ; emetine, 5 milligrams per kilogram; retained.

November 19. Enema, negative; emetine, 5 milligrams per kilogram.

November 20. Enema, negative.

November 21. Ill; sacrificed; extensive bilateral broncho-pneumonia; some hyperæmia of the lower portion of the large bowel; no amœbæ found; total emetine, not over 25 milligrams per kilogram.

STRAIN V; SECOND PASSAGE; CAT 14

Control for Nos. 12 and 13.

November 13, 1921. Weight, 1,820 grams; injected with amœbæ.

November 16. Passed abundant mucus; one amœba found.

November 21. No stools.

November 22. Passing copious amounts of blood and mucus rich in amœbæ.

December 1. Dead; weight, 1,540 grams; had been passing blood and mucus continuously; extreme ulcerations throughout entire large bowel.

STRAIN V; SECOND PASSAGE; CAT 15

Control for Nos. 12 and 13.

November 13, 1921. Weight, 1,940 grams; injected with amœbæ.

November 15. Enema, blood clots but no amœbæ.

November 16. Enema, mucus but no amœbæ.

November 17. Enema; trace of blood and several active amœbæ; incubation period, four days.

November 18. No stools.

November 19. Soft fæcal stool containing a few amœbæ.

November 20. Dead; inflammation in lower bowel with two distinct ulcers.

Six adult cats and one kitten were inoculated for the fifth passage of this strain. Three of the cats remained well.

STRAIN V; FIFTH PASSAGE; CAT 16

December 1, 1921. Weight, 970 grams; injected with amœbæ.

December 4. Enema, mucus, blood, and numerous amœbæ; incubation period, three days; emetine, 7.5 milligrams per kilogram.

December 5. Weight, 920 grams; mucous stool; one minute area in the cover-glass preparation shows numerous active amœbæ; two additional preparations showed no amœbæ; emetine, 7.5 milligrams per kilogram; slight loss after a half hour.

December 6. Enema, negative; emetine, 7.5 milligrams per kilogram.

December 7. Weight, 900 grams; firmly formed stool; no blood nor amœbæ.

December 8. Enema, no blood nor amœbæ.

December 10. Enema, negative.

December 12. Dying; septicæmia; total emetine, not over 22.5 milligrams per kilogram within two days.

STRAIN V; FIFTH PASSAGE; CAT 17

December 1, 1921. Weight, 2,520 grams; injected with amœbæ.

December 4. Enema, moderate amount of blood and numerous amœbæ; emetine, 7.5 milligrams per kilogram.

December 5. Weight, 2,500 grams; enema, mucus; no blood nor amœbæ seen; emetine, 7.5 milligrams per kilogram.

December 6. Weight, 2,520 grams; enema, negative; emetine, 7.5 milligrams per kilogram.

December 7. Weight, 2,500 grams.

December 8. Weight, 2,520 grams; enema, negative.

December 9. Weight, 2,450 grams; enema, negative.

December 15. Enema, firmly formed fæces; no blood nor amœbæ.

January 16, 1922. In good condition; enema, negative.

February 21. Found dead; bilateral broncho-pneumonia; no lesions in large intestine; total emetine, 22.5 milligrams per kilogram within two days.

STRAIN V; FIFTH PASSAGE; CAT 18

December 1, 1921. Weight, 2,070 grams; injected with amœbæ.

December 4. Enema, abundant blood and numerous amœbæ; incubation period, three days; emetine, 10 milligrams per kilogram; slight bloody discharge after fifteen minutes; practically all of the amœbæ are rounded up, and some are disintegrating.

December 5. Enema, negative; emetine, 10 milligrams per kilogram.

December 7. Negative.

December 12. Enema, firmly formed stool, negative.

December 18. Formed stool, negative.

January 4, 1922. Found dead; lungs normal; no lesions in bowel; total emetine, 20 milligrams per kilogram within one day.

STRAIN V; FIFTH PASSAGE; CAT 19

Control for Nos. 16, 17, and 18.
December 1, 1921. Weight, 1,700 grams.
December 3. Enema, some mucus, no amœbæ.
December 4. Enema, blood with active amœbæ.
December 5. No stool.
December 6. Enema, blood and numerous amœbæ.
December 7. Dead; deep ulceration of lower portion of large bowel.

PROPHYLACTIC TESTS WITH EMETINE SUBCUTANEOUSLY

STRAIN V; FOURTH PASSAGE; CAT 20

November 26, 1921. Weight, 670 grams; emetine, 10 milligrams per kilogram subcutaneously; one-half hour later, amœbæ injected.

November 27. Formed stool; refuses milk; no emetine given.

November 28. Weight, 570 grams; enema, one small clot of blood, numerous active amœbæ; incubation period, two days; emetine, 5 milligrams per kilogram subcutaneously.

November 29. Weight, 520 grams; enema, active amœbæ and blood; emetine (rectally), 5 milligrams per kilogram.

November 30. Passing mucus and fair number of amœbæ; emetine (rectally), 5 milligrams per kilogram.

December 1. Sacrificed; extensive lesions of lower part of gut; active amœbæ; total emetine, 25 milligrams per kilogram within four days.

STRAIN V; FOURTH PASSAGE; CAT 21

November 26, 1921. Weight, 620 grams; emetine, 5 milligrams per kilogram, subcutaneously; a half hour later, amœbæ injected.

November 27. Enema, mucus and an occasional amœba; incubation period, one day. Emetine, 5 milligrams per kilogram, subcutaneously; vomited.

November 28. Small blood-tinged stool, amœbæ numerous; emetine, 5 milligrams per kilogram, subcutaneously.

November 29. Blood-tinged stools, active amœbæ; emetine, 5 milligrams per kilogram (rectally).

November 30. Dead; extensive pneumonia on left side; slight superficial inflammation of lowermost part of bowel; total emetine, 20 milligrams per kilogram within three days.

STRAIN V; FOURTH PASSAGE; CAT 22

November 26, 1921. Weight, 570 grams; emetine, 5 milligrams per kilogram, subcutaneously; a half hour later, amœbæ injected.

November 27. Enema, negative; emetine, 5 milligrams per kilogram, subcutaneously; vomited.

November 28. Fæcal stool; enema, negative; emetine, 5 milligrams per kilogram, subcutaneously; drank milk freely.

November 29. Enema, negative.

December 1. Enema, a little mucus; one amœba found; incubation period, five days; very ill; chloroformed; lungs normal; rectum, moderate superficial inflammation; heart-blood culture, *Bacillus pyocyaneus;* total emetine, 15 milligrams per kilogram within two days.

STRAIN V; FOURTH PASSAGE; CAT 23

Control for Nos. 20, 21, and 22.

November 26, 1921. Weight, 510 grams; amœbæ injected.

November 27. Two soft mucous stools; no amœbæ.

November 28. Blood-tinged stool; one motile amœba found in fifteen minutes' search; incubation period, two days.

November 29. Passing blood freely with many amœbæ.

December 1. Very ill; sacrificed; inflammation of rectum with one large ulcer; blood culture, coarse gram-positive bacillus; one other control for this series died the second day after injection of amœbæ; no lesions of bowel.

PROPHYLACTIC TESTS WITH EMETINE PER RECTUM

STRAIN VI; FIRST PASSAGE; CAT 24

December 4, 1921. Weight, 520 grams; emetine, 10 milligrams per kilogram; a half hour later, amœbæ injected.

December 5. Emetine, 5 milligrams per kilogram.

December 6. Enema, negative.

December 8. Enema, negative.

December 10. Enema, negative.

December 12. Enema, blood and amœbæ; incubation period, eight days.

December 13. Sacrificed; extensive inflammation of lower third of large bowel; active amœbæ; blood culture developed a staphylococcus; total emetine, 15 milligrams per kilogram within one day.

STRAIN VI; FIRST PASSAGE; CAT 25

December 4, 1921. Weight, 650 grams; emetine, 5 milligrams per kilogram; a half hour later, amœbæ injected.

December 5. Emetine, 5 milligrams per kilogram.

December 8. Enema, negative.

December 13. Enema, negative.

December 17. Enema, negative.

December 19. Found dead; typical inflammation in lower part of bowel; total emetine, 15 milligrams per kilogram within two days.

STRAIN VI; FIRST PASSAGE; CAT 26

Control for Nos. 24 and 25.

December 4, 1921. Weight, 700 grams; injected amœbæ.

December 7. Enema, abundant blood and amœbæ; incubation period, three days.

December 12. Dead; typical lesions; two older cats weighing 1,650 and 1,700 grams were inoculated as additional controls for this series, but they failed to become infected.

TREATMENT WITH PAPAVERINE AND QUININE

Tests for toxicity.—The fatal dose of papaverine for cats is usually stated to be 100 milligrams per kilogram of body weight injected subcutaneously. Two adult cats were injected per rectum with papaverine hydrochloride in 2 per cent solution, using 50 milligrams per kilogram. On the second day this dosage was repeated in one animal; the other was given 75 milligrams per kilogram. Both became extremely drowsy, but recovered.

The lethal dose of quinine for cats was not determined, but in one animal under treatment the quantity was pushed until toxic symptoms developed. The dihydrochloride was used as a routine in 2 per cent solution. After giving the therapeutic enemata the animals were held as usual with the head downward for a half hour, but on returning them to their cages, a stool was always passed promptly. Therefore, the dosages recorded in the protocols represent merely the amounts injected, the quantity absorbed being necessarily smaller than the recorded figures.

STRAIN VII; THIRD PASSAGE; CAT 27

March 18, 1922. Weight, 1,800 grams; injected with amœbæ.

March 21. Enema, trace of blood and a few typical entamœbæ; incubation period, three days; papaverine hydrochloride, 2 per cent solution, 50 milligrams per kilogram.

March 22. Weight, 1,700 grams; fæcal stool in cage; enema, fæcal matter and one small blood clot; many degenerated cells resembling amœbæ; one nonmotile amœba seen; papaverine, 50 milligrams per kilogram.

March 23. Weight, 1,720 grams; passing blood and numerous amœbæ; quinine dihydrochloride, 2 per cent solution, 200 milligrams per kilogram.

March 24. Enema, no blood nor mucus, one amœba found; quinine, 200 milligrams per kilogram, almost completely expelled; repeated in the afternoon.

March 25. Enema, negative for blood and amœbæ; quinine, 100 milligrams per kilogram.

March 26. Weight, 1,650 grams; enema, blood and mucus and numerous active amœbæ; quinine, 200 milligrams per kilogram.

March 27. Weight, 1,650 grams; enema, negative; quinine, 200 milligrams per kilogram.

March 28. Enema, negative for blood and amœbæ; quinine, 100 milligrams per kilogram.

March 29. Weight, 1,730 grams; enema, negative; no treatment; passed formed stool.

March 30. Weight, 1,700 grams; enema, no blood, a few amœbæ; quinine, 200 milligrams per kilogram.

March 31. Enema, negative.

April 1. Weight, 1,600 grams; passed mucus and amœbæ; quinine, 200 milligrams per kilogram.

April 2. Quinine, 200 milligrams per kilogram.

April 3. Enema, a little mucus; several amœbæ; quinine, 200 milligrams per kilogram.

April 4. Enema, a little mucus and, after twenty minutes' search, one amœba; quinine, 200 milligrams per kilogram.

April 5. Enema, formed stool negative for blood and amœbæ; immediately second enema, blood and mucus and many amœbæ; quinine, 200 milligrams per kilogram.

April 6. Weight, 1,570 grams; enema, numerous amœbæ; sacrificed; extensive deep ulcerations widely distributed throughout the large bowel;

total papaverine, 100 milligrams per kilogram within one day; total quinine, not over 2,200 milligrams per kilogram within fourteen days.

STRAIN VII; THIRD PASSAGE; CAT 28

March 18, 1921. Weight, 1,220 grams; injected with amœbæ.

March 28. Enema, no blood; mucus and a few amœbæ; incubation period, ten days; papaverine, 50 milligrams per kilogram.

March 29. Enema, a little mucus, no blood nor amœbæ; papaverine, 75 milligrams per kilogram.

March 30. Very drowsy; enema, some blood and a few amœbæ; no treatment.

March 31. Dead; lower portion of rectum is filled with blood and the mucosa shows extensive lesions; sections show amœbæ; total papaverine, 125 milligrams per kilogram within one day.

STRAIN VII; THIRD PASSAGE; CAT 29

March 18, 1921. Weight, 1,440 grams; injected with amœbæ.

March 28. Enema, formed stool, some mucus and several amœbæ; incubation period, ten days; quinine (1 per cent), 100 milligrams per kilogram.

March 29. Formed stool in cage; enema, trace of blood and many amœbæ; quinine (2 per cent), 200 milligrams per kilogram.

March 30. Enema, formed stool; no blood nor amœbæ; quinine, 200 milligrams per kilogram.

March 31 to April 13. Formed stools; enema, no blood nor amœbæ.

April 18. Dead; autopsy, lower portion of large bowel contains formed stool; bowel wall is ulcerated and œdematous: smears show definite amœbæ; total quinine, not over 500 milligrams per kilogram within two days.

STRAIN VIII; THIRD PASSAGE; CAT 30

June 5, 1921. Weight, 1,360 grams; injected with amœbæ.

June 7. Enema, negative.

June 8. Passing blood-streaked mucus rich in amœbæ; incubation period, three days; quinine, 200 milligrams per kilogram, in 2 per cent solution.

June 9. Enema, trace of old blood, one amœba; quinine, 200 milligrams per kilogram.

June 10. Enema, some tarry blood, no amœbæ; quinine, 200 milligrams per kilogram.

June 11. Weight, 1,320 grams; enema, negative; quinine, 200 milligrams per kilogram.

June 12. Enema, negative; quinine, 200 milligrams per kilogram.

June 13. Quinine, 200 milligrams per kilogram.

June 14. Weight, 1,280 grams; active and strong, but shows slight muscular tremors and a little nystagmus; treatment discontinued.

June 17. Enema, negative.

June 22. Weight, 1,200 grams; enema, negative.

June 28. Enema, negative.

July 3. Weight, 1,150 grams; enema, negative.

July 15. Weight, 1,150 grams; formed stool; enema, negative; observations discontinued; total quinine, not over 1,200 milligrams per kilogram.

TREATMENT WITH BENZYL BENZOATE

The toxicity of benzyl benzoate proved to be much greater than we had expected. An adult cat injected per rectum with

1.5 cubic centimeters per kilogram, in suspension in normal saline, died within twenty-four hours. A second cat, injected with 0.5 cubic centimeter per kilogram on two successive days, remained well.

STRAIN VIII; FOURTH PASSAGE; CAT 31

June 13, 1921. Weight, 1,570 grams; injected with amœbæ.

June 15. Enema, blood and numerous amœbæ; incubation period, two days; benzyl benzoate, 0.5 cubic centimeter per kilogram; a few drops were expelled containing numerous dead amœbæ.

June 16. Passing fresh blood freely, amœbæ numerous and active; benzyl benzoate, 0.5 cubic centimeter per kilogram.

June 17. Dead; extensive typical lesions of large bowel.

STRAIN VII; FOURTH PASSAGE; CAT 32

Control for Strain VIII.

June 13, 1921. Weight, 1,680 grams; injected with amœbæ.

June 16. Enema, mucus and a few red cells and amœbæ; incubation period, three days.

June 18. Dead; three deep ulcers in large bowel.

III. CLINICAL OBSERVATIONS

Several plants belonging to the family Simarubaceæ are very popular among the peoples native to the Tropics as remedies for the treatment of dysentery; considerable evidence has accumulated indicating their favorable action in amœbic infections. Two of the best known are *Brucea amarissima* (Loureiro) Merrill (*B. sumatrana* Roxburgh), from which is derived the *kho-sam* powder of China, and *Castela nicholsoni* Hooker, or chaparro amargoso, of Mexico. These plants possess an intensely bitter toxic principle, but it has not been identified nor even isolated in sufficient quantity for use in clinical work. Favorable results have been obtained in amœbic dysentery with *C. nicholsoni,* even in cases which failed to respond to emetine. In the work here set forth we have compared the action of *C. nicholsoni* of central America with other members of the Simarubaceæ occurring in the Philippines, with the object of determining whether some of the local species could be used to advantage in place of emetine. In addition to *Castela nicholsoni* two species of other genera were available for study; namely, *Harrisonia perforata* (Blanco) Merrill and *Brucea amarissima* (Loureiro) Merrill. Few of the poorer Filipinos, even though they live in Manila, ever receive adequate and thorough treatment with emetine under satisfactory laboratory control. Simplification of the treatment is urgently needed.

Treatment of dysentery with extracts of the Simarubaceæ has always suffered from the disadvantage that no standardization of dosage has been attempted. In the complete absence of

any guiding information concerning the rather feeble commercial preparations, it is probable that quantities have been used which fall considerably short of both the tolerated and the effective doses. In our work we have prepared some concentrated and highly toxic extracts of two of these plants. No attempt has been made to determine chemically the content of the active principle. The fatal dose for rabbits was estimated in order to secure a general guide for commencing the administration in man.

Method of preparation.—The bitter principle of these plants is soluble in either alcohol or water. Elimination of the greater portions of the gums, resins, chlorophyll, and starch can be readily effected by extracting first with alcohol, evaporating almost to dryness, and then extracting the residue with water. For *Castela nicholsoni* the smaller twigs were ground to a fine powder. The bitter principle of this was extracted by boiling for several hours with methyl alcohol, in the proportion of 1 kilogram of the powder to 5 liters of alcohol. One extraction removed the bitter principle almost completely. After filtration the alcohol was evaporated at low temperature, and a tarry residue was left behind. A quantity of residue representing 12 kilograms of the powdered plant was extracted with 200 cubic centimeters of water divided into small portions. This extract was found to be very toxic for rabbits, 0.1 cubic centimeter injected subcutaneously producing death overnight. For convenience, this quantity of 200 cubic centimeters was diluted to 1 liter. Injected subcutaneously, 1 cubic centimeter of this solution per kilogram killed rabbits within twenty-four hours; 0.5 cubic centimeter produced no symptoms.

The extracts of *Harrisonia perforata* and *Brucea amarissima* were very kindly prepared by Dr. H. I. Cole, of the division of organic chemistry of the Bureau of Science. The extraction of these two drugs was carried out more thoroughly than was done in the case of *Castela;* the toxicity of these extracts represents, roughly but not accurately, the relative toxicity of the corresponding plants. Ethyl alcohol was substituted for methyl. The *Harrisonia perforata* material was shade dried, and the branches and leaves were ground to a coarse powder. Only the seeds of *Brucea amarissima* were used. A rather dilute preparation of *Harrisonia* was employed, of which 2 cubic centimeters represented 1 gram of the original plant. Rabbits were killed in from twenty-four to forty-eight hours by the subcutaneous injection of 15 cubic centimeters of this solution, but

not by 10 cubic centimeters. A more-concentrated solution of *Brucea* was employed. One cubic centimeter represented 4 grams of the original seeds, and subcutaneous injection of rabbits with this amount resulted fatally in from twelve to twenty-four hours; 0.5 cubic centimeter was without any apparent effect.

Clinical results.—All of the patients studied were cases of frank amœbic dysentery, seen either in the first attack or during a typical recidive. Five patients were treated with *Castela nicholsoni,* two with *Brucea amarissima,* and two with *Harrisonia perforata.* Preparations of these plants were always given by mouth, except in one instance, where a few doses were given by injection per rectum. Prompt relief of symptoms, accompanied by the disappearance of amœbæ from the stools, was obtained only with *Castela nicholsoni.* With each of the others, some clinical improvement occurred for a few days, but in three of the four cases the amœbæ persisted and the symptoms returned while the patients were under treatment. In four of the cases treated with *Castela* we have been able to secure an examination of the patient after an interval of several months. One patient relapsed; three remained entirely free of symptoms, although one was passing cysts of *Entamœba histolytica.* The last case illustrates well that freedom from clinical symptoms does not constitute a biological test for the eradication of entamœbæ. However, we would not belittle the value of a drug which affords prolonged clinical relief.

SUMMARY

1. Three species, representing three genera of the Simarubaceæ, were tested for their efficacy in treating amœbic dysentery in man; namely, *Harrisonia perforata* (Blanco) Merrill, *Brucea amarissima* (Loureiro) Merrill, and *Castela nicholsoni* Hooker.

2. *Harrisonia perforata* was not especially toxic for animals; it was readily taken by patients but was inefficacious against amœbæ.

3. *Brucea amarissima* was very toxic for animals, produced nausea readily in patients when taken by mouth, and its action on amœbæ was of little value.

4. *Castela nicholsoni* possesses a distinctly toxic principle, therapeutic doses are well borne by patients, and in five cases it gave prompt relief of symptoms accompanied by the disappearance of the amœbæ.

5. After an interval of several months four of the cases treated with *Castela* were reëxamined. A relapse occurred in

one patient; two others remained perfectly well, but cysts of *Entamœba histolytica* were found in the stool of one; in the fourth no symptoms have appeared, and the stool was negative microscopically on two examinations.

6. This work, taken in conjunction with previous experience, suggests that *Castela nicholsoni* compares very favorably with emetine, both in immediate and in final effects of treatment. The administration of *Castela* can be effected very simply. Neither *Castela nicholsoni* nor emetine, as employed at present, is an ideal agent for the eradication of *Entamœba histolytica* infections in man.

ABSTRACT OF CASES

CASTELA NICHOLSONI

Case 1.—Adult Filipino. Pulmonary tuberculosis. Duration of dysentery ten days. Symptoms started with a chill and fever, and bloody mucous discharges as often as fourteen times daily accompanied by tenesmus. Temperature normal. Stools show numerous *Entamœba histolytica.* Inoculations in kittens produced typical dysentery (Strain II of preceding section). *Castela nicholsoni* started, 2 cubic centimeters being given daily with the evening meal for six days. After the third day of treatment, the number of stools diminished to two or three daily, the blood almost disappeared, but the amœbæ persisted. On the seventh day after starting treatment, an examination of the stools after a saline purge showed a few amœbæ; the dosage of *Castela* was increased to 4 cubic centimeters, given as before, with the evening meal. Three days later no amœbæ were found in the stool and treatment was discontinued. The patient remained apparently well, but ten days after discontinuing treatment, *E. histolytica* was again found in the fæces. *Castela* was given in 4 cubic centimeter amounts daily for three days and the amœbæ again disappeared. The patient was discharged from the hospital eighteen days after treatment was finally discontinued, two successive examinations of the stool after saline purgation showing no amœbæ.

This patient was admitted to the hospital seven months later. He was in an advanced stage of tuberculosis, and the symptoms of dysentery had returned. He was put upon routine treatment of the hospital for dysentery and responded fairly well. He died four weeks later, tuberculosis evidently being an important factor in his death. The autopsy showed tuberculosis of the lungs and intestine, and also some acute amœbic lesions of the large bowel.

Case 2.—Adult Filipino. Onset of dysentery, thirteen years ago. The first attack lasted about sixteen months, and there was one severe recurrence three years ago. The present attack began insidiously a few weeks ago. The patient is now having four to eight bowel movements daily. Large numbers of *Entamœba histolytica* are present. Inoculation of kittens produced typical dysentery (Strain III). A daily dose of 5 cubic

centimeters of *Castela* was given for four days. On the third day after treatment no amœbæ were found in the stools; there was marked constipation during the latter half of the first week after treatment was started. Treatment was suspended for eight days, the stools remaining negative for amœbæ. Then a second course of *Castela* was given, using 5 cubic centimeters daily for one week. An examination of the stools four days after the last dose of *Castela* showed no amœbæ. The patient insisted on leaving the hospital, to return to the harvest fields. He has not been seen since.

Case 3.—Adult Filipina. Duration of disease, four months. During this time there have been several partial remissions and a few isolated doses of emetine have been given. At present the patient is having as many as twenty scanty, bloody, mucous stools daily with much tenesmus. She suffers from general malaise, abdominal pain, and marked tenderness along the ascending, descending, and transverse colon. The stools show numerous *Entamœba histolytica,* and kittens were readily infected (Strain IV). *Castela* was given in 4 cubic centimeter doses daily for one week. Constipation set in after the second dose. A stool obtained by a saline purge on the third day of treatment showed no blood, mucus, nor amœbæ. The patient left the hospital against advice at the end of the first week. This patient was seen nine and one-half months later. She had remained entirely free from symptoms and had gained markedly in weight. An examination of the stool showed no amœbæ, and concentration by the method of Cropper and Row(2) showed no cysts.

Case 4.—Adult Filipina. Onset of dysentery three days ago during convalescence from typhoid fever. Large numbers of *Entamœba histolytica* were present in stool; these were virulent for kittens (Strain IV). Daily doses of *Castela* of 5 cubic centimeters were given for five successive days. Constipation developed on the third day of treatment. A stool specimen examined one week after discontinuing *Castela* was negative for blood and amœbæ. Nine months later the patient was in good health. A specimen of stool showed no amœbæ, and no cysts were found after concentration. A second stool specimen obtained two weeks later after a saline purge was likewise negative.

Case 5.—Filipino child, aged 10 years. Duration of disease two weeks. Acute onset with bloody, mucous stools. *Entamœba histolytica* abundant, producing a typical infection in kittens (Strain V). *Castela* given in 2 cubic centimeter doses daily for eight days. The symptoms improved promptly. On the second day after starting treatment, no amœbæ were seen; on the fourth day a single amœba was found; from the fifth day on the examinations were uniformly negative. Ten days after treatment was discontinued the boy was discharged from the hospital. Eight months later he was found to be entirely free from symptoms. A specimen of stool after salts showed four-nucleated cysts of *E. histolytica.*

BRUCEA AMARISSIMA

Case 6.—Adult American. Has had dysentery off and on for two years. The stools contained blood and numerous *Entamœba histolytica.* Kittens

were easily infected. *Brucea* was given in 1 cubic centimeter doses twice daily and caused vomiting on several occasions. During the first five days of treatment the symptoms improved, and the blood gradually disappeared. The amœbæ became rather scarce, but never disappeared altogether. On account of nausea, rectal administration of *Brucea* was started, giving 4 cubic centimeters daily, diluted with 300 cubic centimeters of water. After the third day of rectal treatment, blood appeared in the stools again, the amœbæ were numerous, and the patient was transferred to specific treatment.

Case 7.—Adult Filipina. Onset of dysentery, ten days ago. The stools consisted of blood-streaked mucus; *Entamœba histolytica* present, but in small numbers. *Brucea* was started in 1 cubic centimeter doses, but caused vomiting very regularly. Nevertheless, three days later the amœbæ disappeared from the stools, but the dysentery continued. The coexistence of bacillary dysentery was suspected, but was not confirmed bacteriologically. The patient did not respond definitely to antidysenteric serum, but the symptoms disappeared gradually without further specific treatment. We are not inclined to attribute the disappearance of the amœbæ to the minimal amounts of *Brucea* that were retained.

HARRISONIA PERFORATA

Case 8.—Adult Filipino. Duration of disease very uncertain. The present attack began about eleven days ago with from six to eight bloody, mucous stools daily. *Entamœba histolytica* was present in considerable numbers. Inoculation of a kitten produced typical dysentery (Strain VI). Treatment was started with 30 cubic centimeter quantities of a dilute preparation of *Harrisonia*, given twice daily. On the second day of treatment, the stools were free from blood, and on the third day no stools were passed; on the fourth day a specimen obtained by a saline purge showed no blood nor mucus, but a few motile amœbæ were present. On the eighth day of treatment bloody, mucous stools were passed, containing fairly numerous amœbæ. The *Harrisonia* was discontinued and benzyl benzoate was substituted, giving 2 cubic centimeters of a 20 per cent solution in alcohol three times daily. During the next three days the symptoms increased in severity and amœbæ persisted in large numbers. Accordingly treatment was commenced with *Castela nicholsoni*, giving 5 cubic centimeters daily for seven days. The symptoms and amœbæ disappeared promptly, and the patient has not been seen since that time.

Case 9.—Adult American. Duration of dysentery one and one-half years, with frequent remissions. Has had one short course of emetine. Acute exacerbation a few days ago. *Entamœba histolytica* was abundant in stools. Kittens were infected (Strain VII). *Harrisonia* was given each evening in 50 cubic centimeter dosage for four days. The number of stools diminished somewhat and the patient felt more comfortable, but the excretion of blood, containing active amœbæ, continued. The dosage of *Harrisonia* was then changed to 20 cubic centimeters, given three times daily. The stools showed blood and amœbæ constantly and, four days later, there was a distinct exacerbation of symptoms. The *Harrisonia* was discontinued and specific treatment started. The quantities of *Harrisonia* given were tolerated without discomfort.

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THE EFFECT OF STASIS ON THE DEVELOPMENT OF AMŒBIC DYSENTERY IN THE CAT

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Extensive experimentation in the transmission of amœbic dysentery to lower animals has served to emphasize three apparently unrelated facts: (*a*) During the subpassage of virulent strains of *Entamœba histolytica* through a long series of kittens, by rectal inoculation, a few individuals from time to time escape infection; on reinoculation these animals are found to be just as susceptible as are normal animals; (*b*) on the contrary, when the cæcum is exposed by laparotomy and the infective material introduced directly through the wall of the cæcum into the lumen of the bowel, then infection takes place with surprising regularity; (*c*) in either case, whether the amœbæ are introduced into the cæcum or injected per rectum, the initial lesions occur in the extreme lower portion of the large bowel.

The occasional failure to infect a susceptible kitten with virulent amœbæ injected per rectum is not of itself remarkable, the conditions naturally being somewhat uncertain as compared with the injection of virulent protozoa and bacteria directly into the tissues. The explanation for the constancy of infection after intracæcal inoculation is not immediately apparent. Indeed, some authors, inexperienced in this mode of inoculation, have denied the value of the procedure. The lesions develop, not at the site of inoculation, but at the opposite end of the large bowel. From the location of the early lesions it would be altogether imposible to determine whether a kitten had been injected per rectum or into the cæcum. In any case, it seems a little strange that the upper two-thirds of the large bowel, which is practically a straight tube in the kitten, should escape damage until after the process has secured a firm foothold in the lowermost portion. It seemed to us not improbable that one single

factor might have an important bearing on these three features. Certainly, the short and straight large intestine of the kitten presents no striking differences along its course. However, the contents of the proximal two-thirds are fluid, while in the lower third there occur formed fæces with moderate secretion of mucus. The question of how *Entamœba histolytica* can injure and penetrate the normal mucosa has been much discussed, but this point of stasis in the distal end of the bowel certainly affords an opportunity for the organisms to gain a foothold. The subsequent dissemination of the lesions indicates that there are no pronounced differences physiologically in the susceptibility of various areas of the large bowel.

The importance of stasis as a factor in determining the location of the initial lesions was tested experimentally. The large intestine of a half-grown cat was exposed by laparotomy under general anæsthesia. A broad ligature was placed around the middle of the bowel and tied tightly enough to obstruct the lumen. A suspension of *Entamœba histolytica,* obtained by sacrificing an infected cat, was injected into the cæcum. There was no indication of any postoperative discomfort. Two days later, the animal was sacrificed. Below the ligature the large intestine was practically free of fæcal matter and showed no lesions. Above the ligature, in the cæcum, 3 centimeters from the point of inoculation, one well-developed lesion was present which contained numerous individuals of *E. histolytica.*

In a second experiment, two adult animals were operated upon in the same way, the ligature being placed at the junction of the upper and the middle thirds of the large bowel. The inoculation of amœbæ was made through the tip of the cæcum. At the same time, ten other animals that were to be used for other work were inoculated per rectum under general anæsthesia. These ten were injected with amœbæ before the inoculations were performed on the two that required operation. The time that elapsed between the sacrificing of the infected kitten for the amœbic material and the completion of the inoculations was one hour and twenty minutes. Of the animals receiving rectal injections, two kittens and one half-grown cat became infected; the other seven remained negative. The two adults, inoculated intracæcally, were sacrificed on the third day. Both showed extensive lesions. In one, the bowel below the ligature contained only clear viscid fluid in which a few individuals of *Entamœba histolytica* were seen. There was no trace of macroscopic lesions. Immediately above the ligature, there was

moderate impaction of fæces. In the cæcal end there was extensive superficial erosion of the mucosa, with a few hæmorrhagic areas. The entamœbæ were extremely abundant in the scrapings from the mucosa. In the other cat, just below the ligature, there was a very little fluid which contained a few amœbæ; otherwise, the distal portion of the bowel was very dry and it was free from any lesion. The contents of the proximal portion were fluid, and practically the entire mucosa of the cæcal end showed superficial lesions. Enormous numbers of *Entamœba histolytica* were present. The results of this experiment are summarized in Table 1.

TABLE 1.—*Inoculation of amœbæ per rectum and intracæcally.*

Cat No.	Weight.	Inoculation.	Result.
	g.		
1	2,370	Per rectum.	Negative.
2	1,820	do	Do.
3	1,970	do	Do.
4	1,820	do	Do.
5	1,600	do	Do.
6	1,370	do	Do.
7	1,360	do	Positive.
8	1,500	do	Negative.
9	800	do	Positive.
10	860	do	Do.
11	2,400	Intracæcal.	Do.
12	2,800	do	Do.

These brief experiments illustrate clearly the importance of stasis as one of the factors in determining the location of the initial lesions in experimental amœbic dysentery in the cat. The distribution of the lesions of amœbic dysentery in man varies considerably. In long-standing fatal cases there is naturally an opportunity for the various portions of the entire large bowel to become involved. Nevertheless, there is a tendency for the ulcerations to predominate, first of all, in the cæcum and ascending colon and, secondly, in the rectum and sigmoid and also at the flexures. These are obviously points at which stasis is likely to occur.

During the past nine months we have on two occasions noted the development of amœbic dysentery during convalesence from typhoid fever. In the observation of more than two hundred cases of Asiatic cholera we have not seen this complication.

The ease with which the two adult cats were infected by intracæcal inoculation is striking. Following the injections per rectum, four adult cats remained well and of four young cats, a

little more than half grown, only one became infected. This illustrates the value of operative procedures for insuring amœbic infection under special conditions. In our own work, in localities where amœbic cases are common, we ordinarily inoculate several kittens per rectum under general anæsthesia, passing a small soft catheter with as little disturbance as possible. However, if young kittens do not happen to be available, or if working in a locality where amœbic dysentery is rare, we always inoculate some animals intracæcally. By this procedure, the amœbæ are introduced into the bowel without breaking up the formed fæces in the rectum, the general anæsthesia and the laparotomy tending to produce constipation.

We have endeavored to utilize some operative procedures in experiments on monkeys. The frequency with which monkeys are parasitized by entamœbæ complicates the interpretation of the results of inoculating them with *Entamœba histolytica.* To obviate some of the difficulty arising from spontaneous infection, the following experiment was carried out. A laparotomy was done on a monkey (*Pithecus philippinensis*) under general anæsthesia, and a ligature was passed around the tip of the rather long cæcum without interfering with the ileocæcal valve. The needle of a syringe was passed through the tip of the cæcum, and the amœbæ were inoculated directly into this sac. It seemed not impossible that in healthy monkeys lesions might be obtained in this sac and not in other parts of the bowel. Thus far, some suggestive but no conclusive results have been obtained.

SUMMARY

1. A laparotomy was performed on three cats under general anæsthesia and a ligature placed around the large bowel in order to produce stasis in its upper end. A suspension of *Entamœba histolytica* was inoculated into the cæcum. All three animals developed lesions above the ligature.

2. This experiment elucidates one factor in explaining (*a*) the usual occurrence of the initial lesions of amœbic dysentery in the cat in the lowermost portion of the large bowel; (*b*) the superiority of intracæcal inoculations over injections per rectum for insuring infection with amœbæ; and (*c*) the occasional failure of virulent amœbæ to infect susceptible kittens.

3. Stasis is probably an important factor in determining the location of the lesions within the large bowel in spontaneous amœbic dysentery in man.

CHEMICAL CHARACTERS OF THE WATERS OF ANGAT AND MONTALBAN RIVERS

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ONE PLATE

At the request of the Metropolitan Water District of Manila, a systematic study of the quality of the waters of Angat River and its most important tributaries was undertaken by the Bureau of Science. This study, however, was limited to the portion within the mountainous regions northeast of Bulacan Province, comprising an area of about 732 square kilometers. No surface water in the Philippine Islands has ever been so systematically and thoroughly studied as has this river water, not even excluding Montalban River, which is the present source of the water supply for Manila.

A survey of the river was made in May, 1921, by a party of chemists of the division of general, inorganic, and physical chemistry of the Bureau of Science for the purpose of taking observations in situ and selecting convenient stations for collecting water samples for analysis.

Six stations were established along the course of the river, within the territory under observation, and their exact locations are shown in the accompanying sketch (Plate 1). The daily collection of samples, at 6 a. m. and at 6 p. m., began May 21, 1921, and continued for one year. Composite samples made up of seven days' collections from each station were forwarded to the laboratory in Manila for analysis.

In as much as no work of this nature had ever been done on the water from the present source of the Manila water supply, it was thought advisable to locate a seventh station, on Montalban River, about 2 kilometers above the dam. The collection of water samples from this station began July 28, 1921.

The work of investigation is now far enough advanced (May, 1922) to justify the discussion of the chemical characteristics of the waters, the relation of their various chemical constituents with the general geology of the drainage areas, and their value for industrial purposes. The notes on the survey and the re-

sults of analyses and observations on the seasonal variation of the physical and chemical properties of the waters will be the subject of another paper, to be submitted, in the form of a report, to the manager of the Metropolitan Water District, in the latter part of the present year.

STATEMENT OF ANALYTICAL RESULTS

The statement of water analyses that is now almost universally adopted is the ionic form. This form, however, is not per se sufficient to permit one to judge the chemical character of a water. For this purpose the reacting value of each individual radicle for a given analysis must be determined.

Stabler defines the reacting value [1] of a radicle as the product obtained by multiplying the quantity of that radicle, expressed in parts per million, by its reaction coefficient. The reaction coefficient, on the other hand, is the capacity of a unit weight of the radicle to enter into chemical reaction. Hence, if

V = capacity for reaction or valence,

W = atomic or molecular weight of radicle,

M = quantity of the radicle in parts per million,

then,

$$\text{Reacting value} = \frac{V \times M}{W}.$$

The value $\frac{V}{W}$ is the reaction coefficient.

The different values of the radicles are thus resolved into quantities that are chemically measurable by a common standard; namely, hydrogen (H), which is the universally accepted standard of reaction.

REACTING VALUES OF RADICLES AND CHEMICAL PROPERTIES OF WATERS

If the different reacting values obtained according to the above formula are expressed in percentages of the concentration value, the peculiar characteristics of a water due to its mineralization will be very much in evidence. Such expressions form the character formula of a water, by means of which it is possible to establish its relation with the general geology of the country. The character formula, or the reacting values, may

[1] The industrial application of water analysis, U. S. Geol. Surv. Water-Supply Paper 274 (1911) 167.

also be employed to study its adaptability for use in various industrial works.

Adopting the methods followed by Chase Palmer,[2] the waters taken from the six stations on Angat River, and the station on Montalban River may be considered under Class 1.

[2] The geochemical interpretation of water analysis, Bull. U. S. Geol. Survey 479 (1911) 11.

The positive radicles determined in water analysis fall into three groups, as follows:

Group A. Alkalies: sodium (Na′), potassium (K′), lithium (Li′).

Group B. Earths: calcium (Ca″), magnesium (Mg″), iron (Fe″).

Group C. Hydrogen (H′).

From these three groups, five special properties are possible, according to the prevalence of the reacting values of the groups measured by the sum of the reacting values of their members, namely:

1. Primary salinity, or alkali salinity.
2. Secondary salinity, or permanent hardness.
3. Tertiary salinity, or acidity.
4. Primary alkalinity, or permanent alkalinity.
5. Secondary alkalinity, or temporary alkalinity.

CLASSIFICATION OF WATERS

If the above groups A and B represent, respectively, the percentage values of alkalies and earths and another group, D, the percentage values of strong acids; namely, sulphates (″SO_4), chlorides (′Cl), nitrates (′NO_3), any one of the following five conditions may occur, representing five different classes of water:

CLASS 1. (D less than A.)

2D	Primary salinity.
2(A−D)	Primary alkalinity.
2B	Secondary alkalinity.

CLASS 2. (D equal to A.)

2A or 2D	Primary salinity.
2B	Secondary alkalinity.

CLASS 3. (D greater than A; less than A+B.)

2A	Primary salinity.
2(D−A)	Secondary salinity.
2(A+B−D)	Secondary alkalinity.

CLASS 4. (D equal to A+B.)

2A	Primary salinity.
2B	Secondary salinity.

CLASS 5. (D greater than A+B.)

2A	Primary salinity.
2B	Secondary salinity.
2(D−(A+B))	Tertiary salinity (acidity).

The following tables show the base data, in parts per million, and the results of computations from which the properties of the waters are derived:

TABLE 1.—*Results of analyses and computations (station 1).*

[Period of observations, May 21 to September 11, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.1	0.396	11.79
Potassium (K)	3.4	0.087	2.58
Calcium (Ca)	15.9	0.794	23.63
Magnesium (Mg)	4.9	0.403	12.00
Iron (Fe)	0.03	0.001	0.03
Sulphate (SO_4)	10.5	0.218	6.48
Chloride (Cl)	7.2	0.203	6.04
Nitrate (NO_3)	0.56	0.009	0.27
Bicarbonate (HCO_3)	76.00	1.249	37.18
Concentration value		3.360	100.00
Colloids:			
Silica (SiO_2)	33		
Alumina (Al_2O_3)	1.03		
Groups:			
Alkalies			14.37
Earths			35.66
Strong acids			12.79
Weak acids			37.18
			100.00
Properties:			
Primary salinity			25.6
Primary alkalinity			3.1
Secondary alkalinity			71.3
			100.00

GENERAL CHARACTER OF THE WATERS

The waters from Angat and Montalban Rivers are characterized by primary salinity and primary alkalinity, which properties are generally associated with the older rock formations, the alkalies of which are their principal soluble decomposition products. Excess of alkalinity also indicates that the carbonates of the alkalies are present in the waters in sufficient quantities to overcome all permanent hardness.

The proportion of silica in these waters is also high. In this connection, Palmer [3] expresses himself in the following way:

[3] Bull. U. S. Geol. Survey 479 (1911) 22.

A high proportion of silica in the mineral content of surface waters is thought by many observers to be normal only to small streams flowing from crystalline siliceous rocks, and especially to those streams near their sources; that is, if silica is a prominent constituent of the inorganic material dissolved in the water of a large stream, its presence must be attributed to some extraneous cause, such as tropical climatic conditions in the drainage basin or abundance of organic matter in the waters.

TABLE 2.—*Results of analyses and computations (station 2).*

[Period of observations, May 21 to September 11, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	8.6	0.374	9.89
Potassium (K)	4.8	0.123	3.25
Calcium (Ca)	19.6	0.979	25.92
Magnesium (Mg)	5.0	0.411	10.88
Iron (Fe)	0.04	0.001	0.03
Sulphate (SO_4)	7.9	0.164	4.34
Chloride (Cl)	7.9	0.223	5.90
Nitrate (NO_3)	0.39	0.006	0.16
Bicarbonate (HCO_3)	91.3	1.498	39.63
Concentration value	---------	3.779	100.00
Colloids:			
Silica (SiO_2)	35.0	---------	---------
Alumina (Al_2O_3)	2.0	---------	---------
Groups:			
Alkalies	---------	---------	13.14
Earths	---------	---------	36.83
Strong acids	---------	---------	10.40
Weak acids	---------	---------	39.63
			100.00
Properties:			
Primary salinity	---------	---------	20.8
Primary alkalinity	---------	---------	5.5
Secondary alkalinity	---------	---------	73.7
			100.0

Looking over the chemical analyses of some river waters in the Philippine Islands,[4] it is apparent that high silica content is a general characteristic of Philippine river waters; on the other hand, analyses of various river waters in the United States [5] show on the average a much lower silica content. These results seem to indicate that the tropical climatic condition is

[4] Heise, G. W., and Behrman, A. S., Philippine water supplies, Bureau of Science publication 11 (1918) 148–151.

[5] Dole, R. B., U. S. Geol. Surv. Water-Supply Paper 236 (1909).

TABLE 3.—*Results of analyses and computations (station 3).*

[Period of observations, May 21 to September 11, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.1	0.396	12.20
Potassium (K)	3.6	0.092	2.83
Calcium (Ca)	15.3	0.764	23.55
Magnesium (Mg)	4.5	0.370	11.40
Iron (Fe)	0.06	0.002	0.06
Sulphate (SO_4)	9.2	0.191	5.92
Chloride (Cl)	7.4	0.209	6.44
Nitrate (NO_3)	0.31	0.005	0.16
Bicarbonate (HCO_3)	74.0	1.215	37.44
Concentration value		3.244	100.00
Colloids:			
Silica (SiO_2)	35.0		
Alumina (Al_2O_3)	2.0		
Groups:			
Alkalies			15.03
Earths			35.01
Strong acids			12.52
Weak acids			37.44
			100.00
Properties:			
Primary salinity			25.0
Primary alkalinity			5.0
Secondary alkalinity			70.0
			100.0

an important factor in the dissolution of the siliceous materials of rocks. It is further observed that the waters of Angat and Montalban Rivers are primarily alkaline; and the solvent action of alkalies on silica, even in very dilute solutions, has long been recognized. The organic matter in these waters is too small to be worthy of consideration.

CHEMICAL PROPERTIES AND GEOLOGY OF THE DRAINAGE AREAS

There is a remarkable similarity in the property values of the waters at station 5 and station 7. Station 5 is situated at Ipo, and station 7 at Montalban River. Both waters are characterized by low primary salinity and high primary alkalinity. On the other hand, the water at station 1 is characterized by high primary salinity and low primary alkalinity. This apparent difference in the chemical characters of the waters at

TABLE 4.—*Results of analyses and computations (station 4).*

[Period of observations, May 17 to August 23, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.7	0.422	11.61
Potassium (K)	1.95	0.050	1.38
Calcium (Ca)	18.3	0.915	25.17
Magnesium (Mg)	5.2	0.427	11.75
Iron (Fe)	0.08	0.003	0.08
Sulphate (SO_4)	10.2	0.212	5.83
Chloride (Cl)	6.9	0.195	5.36
Nitrate (NO_3)	0.25	0.004	0.11
Bicarbonate (HCO_3)	85.8	1.407	38.71
Concentration value		3.635	100.00
Colloids:			
Silica	40.0		
Alumina	2.2		
Groups:			
Alkalies			12.99
Earths			37.00
Strong acids			11.30
Weak acids			38.71
			100.00
Properties:			
Primary salinity			22.6
Primary alkalinity			3.4
Secondary alkalinity			75.0
			100.0

station 1 and station 5 is due to the preponderance of sulphates, which probably are oxidized decomposition products of iron pyrites. It is well to note, in this connection, that a portion of the watershed of Talaguio River is situated within the district of the Angat iron mines, and its waters are sampled at station 1 together with the waters of Maputi and Kailugan. With the exception of the saline waters at Talaguio River, the waters of the various tributaries of Angat River and also those of Montalban River are characterized by primary alkalinity, indicating the predominating influence of beds of decomposed igneous and crystalline granitic rocks in their drainage basins. Secondary alkalinity, causing temporary hardness, is also a conspicuous property common to all these waters, acquired no doubt through contact with limestone deposits.

TABLE 5.—*Results of analyses and computations (station 5).*

[Period of observations, May 17 to August 23, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	8.8	0.383	10.09
Potassium (K)	1.9	0.049	1.30
Calcium (Ca)	17.5	0.878	23.13
Magnesium (Mg)	7.1	0.584	15.37
Iron (Fe)	0.11	0.004	0.11
Sulphate (SO_4)	5.2	0.108	2.84
Chloride (Cl)	6.7	0.189	4.97
Nitrate (NO_3)	0.28	0.004	0.11
Bicarbonate (HCO_3)	97.5	1.599	42.08
Concentration value		3.798	100.00
Colloids:			
Silica (SiO_2)	39.0		
Alumina (Al_2O_3)	2.2		
Groups:			
Alkalies			11.39
Earths			38.61
Strong acids			7.92
Weak acids			42.08
			100.00
Properties:			
Primary salinity			15.9
Primary alkalinity			6.9
Secondary alkalinity			77.2
			100.00

REACTING VALUES AND INDUSTRIAL USEFULNESS

In discussing the industrial usefulness of the waters as computed from the reacting values of their various constituents, use is here made of the formulæ developed by Stabler.[6] The expressions, however, are here recalculated in terms of kilograms per cubic meter of water.

Formula 1.—Lime requirements (100 per cent CaO).

$$CaO = 0.0281 \ (rFe + rAl + rMg + rH + rHCO_3 + 0.0454 \ CO_2).$$[7]

Formula 2.—Soda requirements (100 per cent Na_2CO_3).

$$Na_2CO_3 = 0.053 \ (rFe + rAl + rCa + rMg + rH - (2CO_3 + rHCO_3).$$

[6] The industrial application of water analyses, U. S. Geol. Surv. Water Supply Paper 274 (1911) 165–181.

[7] r = reaction coefficient.

TABLE 6.—*Results of analyses and computations (station 6).*

[Period of observations, May 23 to September 7, 1921. Number of composite samples, 14.]

	Average anlysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.7	0.422	12.10
Potassium (K)	1.8	0.046	1.32
Calcium (Ca)	17.3	0.864	24.78
Magnesium (Mg)	5.2	0.427	12.25
Iron (Fe)	0.07	0.002	0.06
Sulphate (SO_4)	9.2	0.191	5.48
Chloride (Cl)	6.5	0.183	5.25
Nitrate (NO_3)	0.29	0.005	0.14
Bicarbonate (HCO_3)	82.0	1.346	38.62
Concentration value		3.486	100.00
Colloids:			
Silica (SiO_2)	36.0		
Alumina (Al_2O_3)	1.9		
Groups:			
Alkalies			13.42
Earths			37.09
Strong acids			10.87
Weak acids			38.62
			100.00
Properties:			
Primary salinity			21.7
Primary akalinity			5.1
Secondary alkalinity			74.2
			100.0

A negative value indicates that no soda is required.

Formula 3.—Foaming and priming coefficient.

$$F = 62\ (rNa + 1.258\ rK).$$

VALUATION

Nonfoaming	$F < 60$
Semifoaming	$F > 60$, but < 200
Foaming	$F > 200$

Formula 4.—Corrosion coefficient.

$$C = 1.008\ (rH + rAl + rFe + rMg - (rCO_3 + rHCO_3).$$

VALUATION

Corrosive	C, positive
Noncorrosive	$(C + 1.008\ rCa)$, negative
Semicorrosive	$(C + 1.008\ rCa)$, positive[8]

[8] Corrosiveness is directly proportional to the value of $(C + 1.008\ rCa)$.

TABLE 7.—*Results of analyses and computations (station 7).*

[Period of observations, July 28 to November 16, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	8.9	0.390	8.99
Potassium (K)	2.5	0.064	1.48
Calcium (Ca)	25.9	1.293	29.79
Magnesium (Mg)	5.1	0.419	9.65
Iron (Fe)	0.1	0.004	0.09
Sulphate (SO_4)	4.7	0.098	2.26
Chloride (Cl)	7.4	0.209	4.81
Nitrate (NO_3)	0.3	0.005	0.11
Bicarbonate (HCO_3)	113.0	1.858	42.82
Concentration value		4.340	100.00
Colloids:			
Silica (SiO_2)	38.0		
Alumina (Al_2O_3)	2.2		
Groups:			
Alkalies			10.47
Earths			39.53
Strong acids			7.18
Weak acids			42.82
			100.00
Properties:			
Primary salinity			14.4
Primary alkalinity			6.6
Secondary alkalinity			79.0
			100.00

Formula 5.—Scale formation.

(*a*) Total scale.

$$Sc = 0.001\ Sm^{9} + 0.001\ Cm^{10} + 0.036\ rFe + 0.017\ rAl + 0.02\ rMg + 0.06\ rCa.$$

rCa must not exceed the value of $(rCO_3 + rHCO_3 + rSO_4)$.

(*b*) Hard scale.

$$Hs = 0.001\ SiO_2 + 0.02\ rMg + 0.068\ (rCl + rSO_4 - rNa - rK).$$

$$\text{Coefficient of scale hardness } h = \frac{Hs}{Sc}.$$

[9] Suspended matter. [10] Colloidal matter.

VALUATION

Soft scale	$h < 0.25$
Medium scale	$h > 0.25$, but < 0.5
Hard scale	$h > 0.5$

PREFIXES

Very little	$Sc < 0.12$
Little	$Sc > 0.12$, but < 0.24
Much	$Sc > 0.24$, but < 0.48
Very much	$Sc > 0.48$

If the percentage expressions of the various constituents are used instead of their values in milligrams per liter, the results must be multiplied by the expression:

$$\frac{\text{Concentration value}}{100}.$$

TABLE 8.—*Application of formulas and valuation of the waters for industrial purposes.*

[Figures express kilograms per cubic meter.]

Station.	Chemical treatment. CaO required.	Chemical treatment. Na_2CO_3 required.	Foaming and priming properties.	Corrosiveness.	Scale formation.
1	0.046	None	Nonfoaming.	Noncorrosive.	Very little medium scale.
2	0.054	do	do	do	Do.
3	0.045	do	do	do	Do.
4	0.052	do	do	do	Do.
5	0.061	do	do	do	Do.
6	0.050	do	do	do	Do.
7	0.064	do	do	do	Little medium scale.

The results shown in Table 8 are self-explanatory as to the quality of the waters for industrial purposes.

SUMMARY

The general characteristics of the waters of Angat and Montalban Rivers are primary salinity and secondary alkalinity. The alkalies are also present in sufficient quantities to overcome all permanent hardness.

The high sulphate content of the waters at Stations 1, 3, 4, and 6 is probably due to the oxidized decomposition products of iron pyrites with which Talaguio River appears to be contaminated.

The waters are nonfoaming, noncorrosive, and, from a chemical point of view, they may be considered satisfactory for general public consumption.

ILLUSTRATION

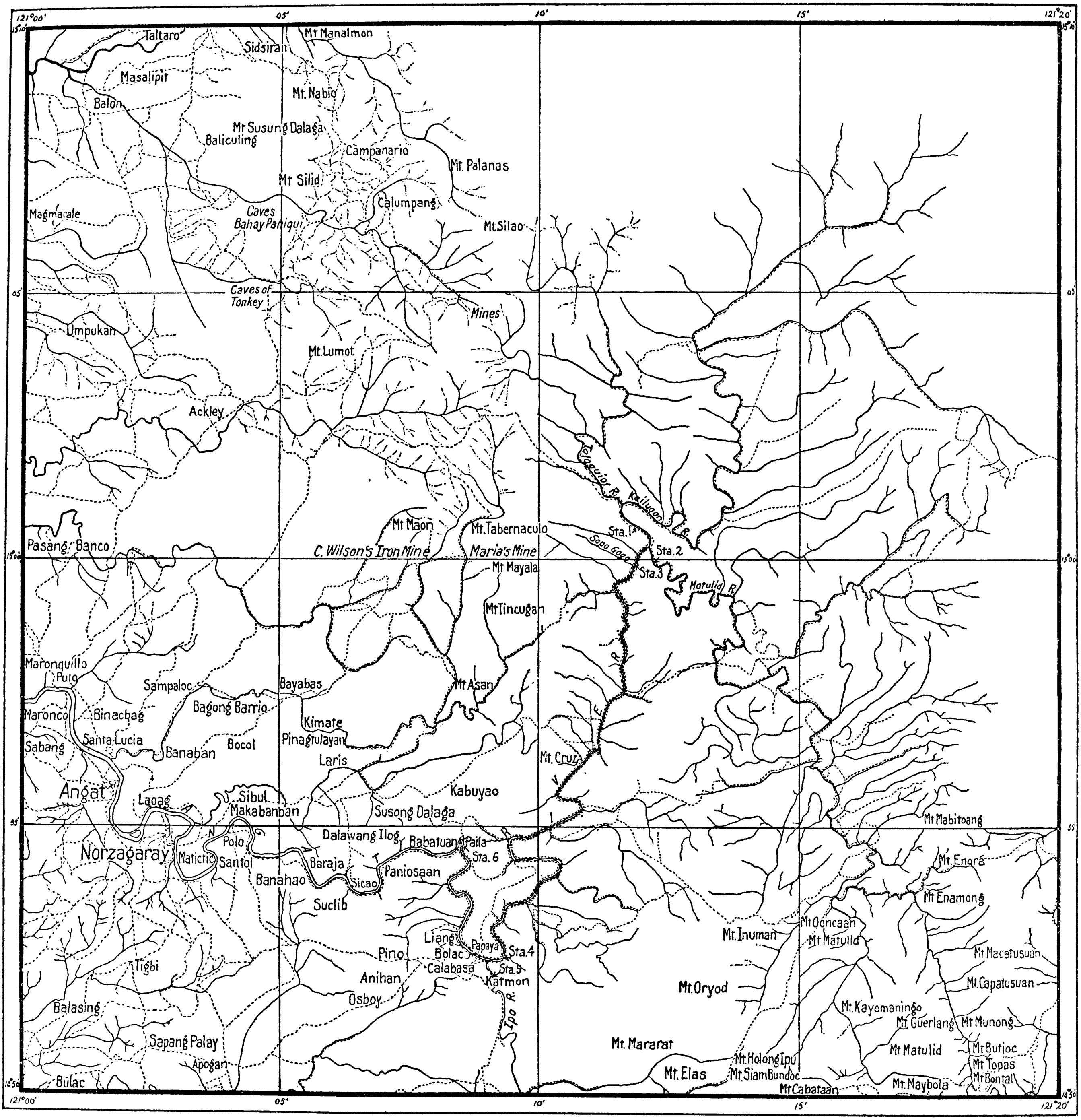

PLATE 1. ANGAT RIVER WATERSHED, SHOWING THE LOCATION OF SIX STATIONS.

LYCOPODIACEAE PHILIPPINENSES

Von W. Herter
Berlin, Germany

Vor einem Jahrzehnt sandte mir der bekannte Botaniker der Philippinen, Herr Elmer D. Merrill, Director, Bureau of Science, Manila, eine wertvolle Sammlung philippinischer Lycopodien zur Bearbeitung nach Porto Alegre, Rio Grande de Sul, meiner damaligen Wirkungsstätte. Als ich bald darauf, im Jahre 1913, nach Deutschland zurückkehrte, gelang es die Sammlung nach Berlin-Dahlem zu schaffen, wo ich sie an der Hand des Herbariums des Botanischen Museums bearbeiten konnte und wo ich im Jahre 1915 ein Manuskript über die Lycopodiaceen der Philippinen fertigstellte. Dieses Manuskript verschwand spurlos während meines Sanitätsdienstes bei der Ostarmee, sodass eine unliebsame Verzögerung der Drucklegung eintrat und ich nach meiner Rückkehr nach Berlin die Arbeit von neuem anfangen musste. Kurz vor Abschluss der Neubearbeitung übersandte mir im Jahre 1921 Herr Merrill eine weitere, noch reichhaltigere Lycopodiensammlung, die in der Zwischenzeit auf den Philippinen zusammengebracht worden war und die im Verein mit der ersten Sammlung ein recht vollständiges Bild der Lycopodiaceenflora jener Inseln ergibt.

Im Folgenden habe ich die Ergebnisse meiner Studien der beiden Sammlungen zusammengestellt.

ERSTER TEIL

SCHLÜSSEL DER GATTUNGEN, UNTERGATTUNGEN, SEKTIONEN, UND ARTEN

Die Familie der Lycopodiaceen zerfällt in zwei Gattungen: *Urostachys* und *Lycopodium.*

Genus UROSTACHYS Herter

Verzweigung in allen (vegetativen und reproduktiven) Teilen bipartit mit gleichmässiger Weiterentwickelung. Infolgedessen fehlt eine Hauptachse. Wurzeln in Büscheln nahe dem Anfangsende der Pflanze, soweit sich dieses am Boden befindet, nur ausnahmsweise Adventivwurzeln an sonstigen dem Substrat genäherten Stellen der Pflanze. Bisweilen Brutknospen am ober-

en Ende der Pflanze. Sporangien am ganzen Stamm verteilt oder nur an den Zweigenden in undeutlich, seltener deutlich abgesetzten, ungestielten, bisweilen sehr langen und viel verzweigten Blüten, die stets geringeren Durchmesser haben als die vegetativen Teile. Sporophylle (Sporangien tragende Blätter) den Blättern meist gleich oder ähnlich gestaltet und gefärbt, seltener stark verschieden, dick und gekielt. Sporen glatt oder unregelmässig rauh, mit punktförmigen Vertiefungen. Geschlechtsorgane mit Paraphysen. Am Boden oder auf Bäumen lebende, aufrechte oder herabhängende, gleichmässig beblätterte Pflanzen.

a^1. Sporophylle den Blättern gleich gestaltet oder von ihnen verschieden; im letzteren Falle (Sectionen *Squarrosurus* und *Carinaturus*) unmerklicher Uebergang zwischen beiden, selten sind deutlich abgesetzte Blüten vorhanden, dann ist jedoch eine mindestens 2 cm lange Uebergangszone zwischen vegetativem Teil und Blüte vorhanden und letztere ist breiter als 3 mm. Aufrechte Geophyten und hängende Epiphyten.................... Subgenus **Euurostachys** Hert.

b^1. Sporophylle und Blätter völlig oder ziemlich gleichgestaltet. Oft Brutknospen vorhanden. Keine eigentlichen Blüten.

c^1. Geophyten. Aufrechte, meist 10–20 cm hohe Pflanzen. Blätter linearisch oder lanzettlich. Brutknospen vorhanden.
Sectio *Selaginurus* Hert.

d^1. Höhe 10 cm. Blätter in der Nähe des Blattgrundes am breitesten, mittlere Breite 0.3 mm........................ 1. **U. minimus** Hert.

d^2. Oft 20 cm hoch und höher. Blätter in der Nähe der Blattmitte am breitesten, oft über 1 mm. breit.
2. **U. serratus** (Thunb.) Hert.

c^2. Epiphyten. Herabhängende, 30–300 cm lange Pflanzen. Blätter fadenförmig. Durchmesser der Zweige (einschliesslich der Blätter) oben und unten gleich. Blätter 3–7 mm lang. Keine Brutknospen. Sectio *Tenuistachys* Hert.
3. **U. verticillatus** (L.) Hert.

b^2. Sporophylle und Blätter meist recht verschieden gestaltet, jedoch allmählich in einander übergehend. Ohne Brutknospen. Ephiphyten.

c^1. Blüten kaum oder deutlicher abgesetzt, Sporophylle und Blätter wenig oder stärker verschieden, Sporophylle nicht oder schwach gekielt. Blätter linearlanzettlich, wagerecht abstehend, lederig, flach. Pflanzen kräftig, meist aufrecht. Stamm ohne Blätter, an der Basis oft über 5 mm dick.......... Sectio *Squarrosurus* Hert.

d^1. Blüten gewöhnlich breiter als 10 mm, seltener an der Spitze nur 6–8 mm breit. Sporophylle abstehend, den Blättern meist sehr ähnlich, 0.5–1.5 x 6–8 mm gross.
4. **U. squarrosus** (Forst.) Hert.

d^2. Blüten in der Mitte 4–8 mm breit. Sporophylle anliegend, von den Blättern abweichend gestaltet, 1–1.5 x 4–5 mm gross.

e^1. Blüten in der Mitte 6–8 mm breit. Blätter glänzend. Sporophylle 1.5 x 5 mm gross........................ 5. **U. Magnusianus** Hert.

e^2. Blüten in der Mitte 4–5 mm breit, Blätter nicht glänzend. Sporophylle 1 x 5 mm gross..................... 6. **U. Whitfordi** Hert.

c^2. Sporophylle und Blätter völlig verschieden, erstere stets scharf gekielt. Pflanzen meist schlaff herabhängend. Stamm ohne Blätter bis 3 mm dick................................. Sectio *Carinaturus* Hert.

d^1. Blätter linearlanzettlich, lederig, wagerecht abstehend, flach, abwärts gekrümmt, Sporophylle mässig starr.
7. **U. Toppingi** Hert.

d^2. Blätter aufrecht abstehend, Sporophylle sehr starr und regelmässig gestellt.

e^1. Untere Blätter starr linearisch, Blätter 8 mm lang.
8. **U. carinatus** (Desv.) Hert.

e^2. Untere Blätter lanzettlich, lederig, 10–12 mm lang.
9. **U. Merrilli** Hert.

a^2. Sporophylle von den Blättern stets verschieden, ganz bedeutend kleiner als diese, meist breit eiförmig. Blüten scharf abgesetzt, oft gegabelt, bisweilen durch fadenförmige Schlankheit ausgezeichnet, meist 1–2, selten bis 5 mm breit. Herabhängende Epiphyten.
Subgenus **Heterourostachys** Hert.

b^1. Blätter gespitzt.. Sectio *Phlegmariurus* Hert.

c^1. Blätter mehr als doppelt so lang als breit.

d^1. Blüten dicker als 3 mm, wenig verzweigt. Schlaff herabhängend.
10. **U. pinifolius** (Blume) Hert.

d^2. Blüten dünner als 3 mm, Gebeläste oft stark spreizend und vielfach gekrümmt.

e^1. Blätter dicht, aufrecht abstehend, fest, lederig, 4–5 x 15–20 mm lang, Stamm oft 3 und mehr mm ohne die Blätter breit; Sporophylle dicht stehend, etwa so breit als die Sporangien, diese meist bedeckend. Robuste Pflanze..11. **U. Elmeri** Hert.

e^2. Blätter locker abstehend, meist 10 mm lang oder kürzer.

f^1. Blätter 1–3 mm breit........................ 12. **U. banayanicus** Hert.

f^2. Blätter 4–5 mm breit.................. 13. **U. phlegmaria** (L.) Hert.

c^2. Blätter nur wenig länger als breit, eiförmig, stumpf gespitzt.
14. **U. salvinioides** Hert.

b^2. Blätter nicht gespitzt, umgekehrt eiförmig. Blüten 3–4 mm dick. Sectio *Nummulariifoliurus* Hert.................... 15. **U. Delbrückii** Hert.

Genus LYCOPODIUM (L.) Herter

Verzweigung nur in der Jugend (bei älteren Pflanzen meist nur in den jüngeren reproduktiven Teilen) bipartit mit gleichmässiger Weiterentwickelung; später kommt durch ungleichmässige Weiterentwickelung eine Hauptachse zustande, die über oder seltener unter dem Erdboden hinkriecht oder im Gesträuch hochklettert. Sie ist bisweilen sehr kurz (*Lateralistachys*) oder erscheint bei den Halbsträuchern (*Cernuostachys*) in Form von Ausläufern oder Verbindungsgliedern mehrerer, anscheinend selbständiger Pflanzen. Diese Verbindungsglieder fehlen in Herbarien, wenn nur der obere Teil der Pflanze gesammelt

worden ist. Wurzeln in regelmässigen Abständen an der Hauptachse. Brutknospen am oberen Ende der Pflanze fehlen. Sporangien nie am ganzen Stamm verteilt, sondern in mehr oder weniger deutlich abgesetzten endständigen oder seitlichen (*Lateralistachys*) walzen- oder kätzchenförmigen, von den vegetativen Teilen meist durch spärlicher beblätterte Zwischenstücke von geringerem Durchmesser (Blütenstiele) getrennten Blüten. Sporophylle von den Blättern meist stark verschieden, von bleicher oder bräunlicher Farbe, am Rande gezähnt oder gewimpert, oft zart häutig, nie dick und gekielt. Sporen mit erhabenen, netzartigen Verdickungen oder Stacheln. Geschlechtsorgane ohne Paraphysen. Geophyten oder Kletterer, bei denen die Differenzierung in Bezug auf Verzweigung und Beblätterung fortgeschrittener erscheint.

a[1]. Blüten am Ende der Zweige oder Blütenstiele.
Subgenus **Acrostachys** Hert.

b[1]. Bodenkriecher. Blüten wenige (meist nur 1–20 an jeder Pflanze). Schleimgänge fehlen......Sectio *Eulycopodium* Hert. *Clavatostachys* und *Complanatostachys* Hert. olim.

c[1]. Blätter von einerlei Art, radiär abstehend. Blüten an langen, blattarmen Stielen.. 1. **L. clavatum** L.

c[2]. Blätter von zweierlei Art, bilateral gestellt, die seitlichen flach, nach oben gekrümmt, abstehend, breit, herablaufend, die vorderen und hinteren (oberen und unteren) kleiner, linear, angedrückt.

d[1]. Auch die grösseren Blätter kurz schuppenförmig, bis 2 mm lang, starr spitzig, Zweige mit den Blättern kaum breiter als 2.5 mm. Blüten zu mehreren am Ende der Zweige.
2. **L. complanatum** L.

d[2]. Grössere Blätter bis 5 mm lang, kammförmig abstehend, linear lanzettlich. Zweige aufsteigend, mit den Blättern 5 mm breit. Blüten einzeln am Ende der Zweige.
3. **L. scariosum** Forst.

b[2]. Meterhohe Halbsträucher mit ausläuferartiger Hauptachse (die im Herbarium oft fehlt) oder mit der Hauptachse meterhoch kletternde Pflanzen. Blüten zahlreich, oft 50–100 und mehr.
Sectio *Cernoustachys* Hert.

c[1]. Aufrechte Halbsträucher. Blüten als kurze walzenförmige Kätzchen stiellos an den Enden der beblätterten Zweige. Sporophylle mit langer Spitze, gewimpert. Blätter linear-pfriemlich, mit stark hervortretender Mittelrippe und Schleimgängen.
4. **L. cernuum** L.

c[2]. Kletternde Pflanzen. Blüten als gekrümmte Kätzchen an vielfach verzweigten, blattarmen Stielen. Schleimgänge fehlen.

d[1]. Vegetative Teile radiär gebaut. Jugendform mit pfriemlich-linearen, abstehenden, Altersform mit schuppigen, angepressten, herablaufenden Blättern. Endzweige oft hängend, rot.
5. **L. casuarinoides** (Spring).

*d*². Vegetative Teile bilateral gebaut, zwei Reihen seitlicher, sichelförmiger, oft zusammenhängender und zwei Reihen dorsaler, nebeneinander stehender, kleiner, angepresster Blätter. Ueber 10 m hoch kletternd.............................. 6. **L. volubile** Forst.

*a*². Wenig verzweigte, niedrige Kräuter mit reduzierter (in Herbarien meist fehlender) Hauptachse, Aeste aufrecht, Blüten seitlich aus den Zweigen hervorkommend. Blätter linear. Subgenus **Lateralistachys** Hert.. 7. **L. halconense** Copel.

ZWEITER TEIL

AUFZÄHLUNG DER ARTEN MIT STANDORTEN. BESCHREIBUNG DER NEUEN ARTEN

Genus **UROSTACHYS** Hert. in Beih. Bot. Centralbl. Abt. II 1922. *Lycopodium* Subgenus I. *Urostachys* Hert. in Engl. Bot. Jahrb. **43** (1909) Beibl. **98**: 29.

Subgenus **Euurostachys** Hert. op. cit. 30. sensu emend.

Sectio SELAGINURUS Hert. l. c.

UROSTACHYS MINIMUS Hert. sp. nov.

Radix brunnea, fasciculata, pluries bipartita, long. 15 mm, lat. 0.2 mm. Frons viridis, bis-ter bipartita, suberecta v. subflexuosa, tenerrima, alt. 6–8 cm, lat. 4–6 mm foliis inclusis, 0.5 mm foliis exclusis. Folia viridia, ± sexfaria, subdensa, horizontaliter patentia, tenera, lineari, 2–4 x 0.2 mm. Sporangia deficiunt. Planta affinis *U. vernicoso*, sed multo minor, odore typico Lycopodiacearum.

MINDANAO, Davao District, Mount Apo, *Elmer 11560*, August, 1909, herb. Manila.

UROSTACHYS SERRATUS (Thunb.) Hert. comb. nov.
Lycopodium serratum Thunb. Fl. Jap. (1784) 341, *t. 38*.

Area geogr.: As. orient. subarct., temp., subtrop., trop. Ins. Philipp.: LUZON, Lepanto Subprovince, Mount Data, *Copeland 1864:* Bontoc Subprovince, Malawey, *Vanoverbergh 487:* Benguet Subprovince, Pauai, Mount Ugo, Mount Tonglon, *Bur. Sci. 31987 Santos, 4229, 4464 Mearns, 5810 Ramos, 8382 McGregor, For. Bur. 10835 Curran, Merrill Phil. Pl. 906, Topping 1177, Clemens 9228:* Laguna Province, Mount Banahao, *Merrill 7510, Copeland s.n., Bur. Sci. 19569 Ramos.* MINDORO, Mount Halcon, *Merrill 6022, 6023.* NEGROS, Canlaon Volcano, *Merrill 6954.* MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4648, 4649 Mearns & Hutchinson:* Agusan Province, Mount Urdaneta, *Elmer 14094.* An bemoosten Stämmen in Gebirgswäldern in Höhen von 1,600–2,800 m.

Nom. vulgare: Kodlala (Ig.); sinang padayo (Bon.).

Sectio TENUISTACHYS Hert. l. c.

UROSTACHYS VERTICILLATUS (Linn. f.) Hert. comb. nov. var. γ **MAXIMA** (Hert.) comb. nov.

Lycopodium verticillatum Linn. f. Suppl. (1781) 448, γ *maximum* Hert. in Engl. Bot. Jahrb. 54 (1916) 227.

Var. δ **GIGANTEUS** Hert. var. nov.

Differt diametro giganteo partium sterilium (12–15 mm) et partium fertilium (8–15 mm).

Area geogr. Circumtrop. Ins. Philipp.: LUZON, Ifugao Subprovince, Mount Polis, *Merrill Phil. Pl. 1277* coll. *McGregor*, δ. MINDORO, Mount Halcon, *Merrill 6026*, γ. MINDANAO, Davao District, Mount Matutum, *Copeland* s. n., γ & δ; Mount Apo, *Elmer 11659*, γ: Misamis Province, Mount Malindang, *Bur. Sci. 4652, 4653 Mearns & Hutchinson*, δ. An bemoosten Stämmen in Gebirgswäldern in Höhen von 1,500–2,400 m.

Sectio SQUARROSURUS Hert. sect. nov. Series *Squarrosa* Hert. op. cit. 36.

UROSTACHYS SQUARROSUS (Forst.) Hert. comb. nov.

Lycopodium squarrosum Forst. Prodr. (1786) 86 (Tahiti?).

Var. α **TYPICA.**

Pars fertilis diam. 12–15 mm, folia majora lat. 1–1.5 mm.

Var. β **INTERMEDIA.**

Pars fertilis diam. 10 mm.

Var. γ **TENERA.**

Pars fertilis interdum ad apicem versus non magis quam 6–8 mm diam.; folia minora, lat. 0.5–0.8 mm.

Area geogr.: Regn. paleo-trop.- Ins. Philipp.: BABUYAN ISLANDS, Camiguin, *Bur. Sci. 4142 Fénix*, γ. LUZON, Bontoc Subprovince, Malawey, *Vanoverbergh 489:* Benguet Subprovince, Baguio, *Elmer 6026*, α, *Lete 394*, α, *Topping 230*, α, *Phil. Pl. 1046 Fénix*, α: Tayabas Province, Sampaloc, *Holman 198:* Zambales Province, Mount Tapulao, *Bur. Sci. 5003 Ramos*, β: Pampanga Province, Mount Abu, *Bur. Sci. 1969 Foxworthy*, β: Bataan Province, Mount Mariveles, *Topping 376*, α, *Whitford 325*, α, *Merrill 3959*, β: Albay Province, Mount Mayon, *Bur. Sci. 6463 Robinson*, α. PANAY, Iloilo Province, Ulian River, *Bur. Sci. 18199 Robinson*, β. MINDORO, Mount Halcon, *Merrill 6027*, α, *6028* β. NEGROS, Canlaon Volcano, *Banks*. MINDANAO, Agusan Province, Mount Urdaneta, *Weber 1161*, β & γ, *Elmer 14165*, β: Misamis Province, Mount Malindang, *For. Bur. 4656, 4657, 4658 Mearns & Hutchinson*, α: Lake Lanao, *Clemens*, *s.n.*, α, Lanao–Cotabato trail, *For. Bur. 25236 Alvarez*, β: Davao District, Mount Apo, *Copeland 999*, α, Elmer *10783*, γ. In

feuchten Wäldern, meist an bemoosten Stämmen, in Höhen von 100–2,500 m.

Nom. vulgare: Padayau (Ig.).

UROSTACHYS MAGNUSIANUS (Hert.) Hert. comb. nov.

Lycopodium Magnusianum Hert. in Hedw. 49 (1909) 91.

Frons lat. basi 16–18 mm foliis inclusis. Flores long 6–8 cm, lat. (6–) 8 mm foliis inclusis.

Area geogr. Ins. Philipp.: MINDANAO, Lamao District, Camp Keithley, *Clemens s. n.* Herb. Man., Herb. Berl. Typus der art!

UROSTACHYS WHITFORDI Hert. sp. nov.

Lycopodium squarrosum var. *McGregorii* Christ in litt. 1905; var. *Whitfordi* Christ et var. *humilis* Christ nom. nud. in Herb. Man.

Radix fasciculata. Frons luteo- sive brunneo-viridis, sexies-octies bipartita, primum probabiliter erecta, deinde pendula, long. 60–100 cm, lat. 20–25 mm foliis inclusis. Caulis rigidus, basi diam. 6–8 mm foliis exclusis. Flores bipartiti, long. saepius 20–30 cm, lat. ad basim 6–8, ceterum 4–5 mm. Folia ± duodecimfaria, densissima, patentia, saepius incurvata, acumine aut ad basin aut ad apicem spectantia, subrigida, sed non crassa, lanceolata, longe acuminata, nec carinata, nec nitida, 1–2 x 8–12 mm.

Sporophylla densissima, erecto-patentia, lanceolata 1 x 4–6 mm, sporangia obtegentia. Sporangia lat. vix 1 mm. Planta epiphytica proxime affinis *U. squarroso* et *U. Magnusiano,* quibus floribus longis et 4–5 mm latis differt.

Area geogr. Ins. Philip.: LUZON, Tayabas (Infanta) Province, *Whitford 798,* Typus der Art! PANAY, Capiz Province, Mount Madiaas, *Bur. Sci. 30687 Ramos & Edaño;* Mount Salibongbong, *Bur. Sci. 35624 Martelino & Edaño.* MINDORO, Baco River, *McGregor 293.* LEYTE, Dagami, *Wenzel 507.* MINDANAO, Surigao Province, *Bolster 358.* BASILAN, *Bur. Sci. 16219 Reillo.* In Wäldern, von Meereshöhe bis 600 m.

Nom. vulgare: Lumayi (Tag.).

Sectio CARINATURUS Hert. op. cit. 30.

UROSTACHYS TOPPINGI Hert. sp. nov.

Radix ramosissima. Frons sordide brunneo-viridis, long. 20–25 cm, quater bipartita, pendula. Caulis basi 2 mm diam. foliis exclusis. Partes steriles 10 (–15) cm lat. foliis inclusis, abruptim in flores transeunt. Flores bipartiti, long. 10 cm, lat. 10 mm. Folia ± octofaria, densa, lineari-lanceolata, plana, acuminata, reflexa, apice ad basim spectante, nervo vix promi-

nente, 1 x 8 mm. Sporophylla quinque-sexfaria, densa, erecto-patentia, lineari-lanceolata, acuminata, carinata, 1 x 4–5 mm. Planta epiphytica intermediaria inter sectiones *Squarrosurus* et *Carinaturus,* primo visu affinis *U. reflexo* videtur foliis angustis lineari-lanceolatis planis reflexis.

Area geogr. Ins. Philipp. LUZON: Benguet Subprovince, Sablan Trail, *Topping 1096* herb. Man. Jan. 1909.

UROSTACHYS CARINATUS (Desv.) Hert. comb. nov.

Lycopodium carinatum Desv. in Lam. Encycl. Suppl. 3 (1823) 559.
Lycopodium gnidioides Blanco Fl. Filip. (1837) 824, non Linn.

Area geogr. As. et Austral. trop. Ins. Philipp.: LUZON, *Haenke 48,* Herb. Berl., *Cuming 2009, 2360* Herb. Berl., Paris, Kew, Delessert: Tayabas Province, *Whitford 813, For. Bur. 9575 Curran:* Bataan Province, Mount Mariveles, *Merrill 152:* Laguna Province, San Antonio, *Bur. Sci. 14950 Ramos.* POLILLO, *Bur. Sci. 10780 McGregor, 9252 Robinson.* MINDORO, Baco River, *Merrill 1245,* MINDANAO, Agusan Province, Bunawan, *Taylor 167:* Lanao District, Camp Keithley, *Clemens 746:* Davao District, *Warburg 14200* Herb. Berl. An Waldbäumen im Flachland bis zu Höhen von 1,200 m.

UROSTACHYS MERRILLI Hert. sp. nov.

Radix fasciculata. Frons sordide luteo- s. brunneo-viridis, flaccide pendula, quinquies bipartita, long. 50 cm. Caulis basi diametro 1–2 mm foliis exclusis. Partes steriles basi 15 mm, apice 10 mm foliis inclusis, abruptim in flores transeunt. Flores bis-quater bipartiti, long. 30 cm, lat. 4–6 mm. Folia sex-octofaria, subdensa, erecto-patentia, subregulariter disposita, ovato-lanceolata, plana, non crassa, acuminata, nervo infra prominente, 2–3 x 8–12 mm. Sporophylla densiora, quadri-sex-faria, erecto-patentia, regulariter disposita, non crassa, lanceolata, carinata, 2–2.5 x 5–6 mm. Planta epiphytica intermedia inter *U. carinatum* et *U. phlegmariam.* Differt ab *U. carinato* textura laxa foliisque planis.

Area geogr. Ins. Philipp.: LUZON, Benguet Subprovince, Mount Lusod, *For. Bur. 15760 Curran & Merritt;* Mount Tonglon (Santo Tomas), *Merrill Phil. Pl. 965* (Typus der Art!), *Elmer 6619, For. Bur. 5064 Curran;* Mount Pulog, *Bur. Sci. 8836 McGregor, For. Bur. 16322 Curran, Merritt, & Zschokke;* Pauai, *Topping 1156, Bur. Sci. 31819 Santos, 8477 McGregor:* Lepanto Subprovince, Mount Data, *Copeland 1872, For. Bur. 10966 Curran:* Bontoc Subprovince, Malawey, *Vanoverbergh 671.* An bemoosten Stämmen in Gebirgswäldern in Höhen von 1,600–2,400 m.

Subgenus **Heterourostachys** Hert. op. cit. sensu restr.

Sectio PHLEGMARIURUS Hert. op. cit.

UROSTACHYS PINIFOLIUS (Blume) Hert. comb. nov.
Lycopodium pinifolium Blume Enum. Pl. Jav. 2 (1828) 264.

Ich stelle die vorliegenden Pflanzen mit Vorbehalt zu *U. pinifolius*, vielleicht wären sie besser als eigene Art zu betrachten. Das gleiche gilt von einigen Pflanzen von Nordluzon und Mindanao, die ich vorläufig als Varietät betrachte.

Var. *β*. Differt foliis tenerribus, habitu *U. verticillati*.

Area geogr. Ins. Sund. Ins. Philipp.: BATAN ISLANDS, Batan, Mount Iraya, *Bur. Sci. 3828 Fénix*. LUZON, Ilocos Norte Province, Mount Palimlim, *Bur. Sci. 33248 Ramos:* Abra Province, Mount Posuey, *Bur. Sci. 27000 Ramos, β*: Benguet Subprovince, Mount Tonglon (Santo Tomas) *Topping 1202, Elmer 6619 p.p., Bur. Sci. 5352 Ramos;* Mount Ugo, *Bur. Sci. 5815 Ramos:* Bataan Province, Mount Mariveles, *Whitford 166, Topping 359, Merrill 3219:* Laguna Province, Mount Banahao, *Copeland s.n.* MINDANAO, Agusan Province, Mount Urdaneta, *Elmer 14080, β:* Misamis Province, Mount Malindang, *For. Bur. 4620, 4655 Mearns & Hutchinson:* Lanao District, Camp Keithley, *Mrs. Clemens s. n.*

An bemoosten Bäumen in Höhen von 1,000–2,400 m.

UROSTACHYS ELMERI Hert. sp. nov.

Radix densiter fasciculata, long. 5 cm. Frons brunnea, viridis vel brunneo-viridis, ter-quater bipartita, primum probabiliter erecta, deinde pendula, long. 30–70 cm, lat. 2–4 cm foliis inclusis. Caulis rigidus, basi diam. 3 mm foliis exclusis. Flores ter-quater bipartiti, long. 5–20 cm, lat. 1.5 (–3) mm. Folia ± octofaria, densa, erecto-patentia, rarius subhorizontaliter patentia vel reflexa, coriacea, lanceolata, acuta, nitida, infra subcarinata, marginibus subrevolutis, 3–5 x 15–20 mm. Sporophylla densissima, lanceolata, erecto-patentia seu appressa, ± quadrifaria, subcarinata, sporangia subtegentia, 1 x 2–3 mm. Sporangia lat. vix 1 mm. Planta epiphytica proxime affinis *U. phlegmariae* et *U. banayanico* a quibus imprimis foliis densis coriaceis majoribus differt.

Area geogr. Ins. Philipp.: Herb. Willdenow *"Lycopodium mirabile"*. LUZON, Benguet Subprovince, Twin Peaks, *Elmer 6411:* Tayabas Province, *Bur. Sci. 5805 Savella;* Mahaihai *Wichura 1932:* Rizal Province, Tanay, *Merrill 2313, Bur. Sci. 15168 Reillo.* MINDORO, Baco, *Merrill 1246.* CULION, *Merrill 497.* PALAWAN, *Bur. Sci. 372 Bermejos, For. Bur. 3906 Curran.*

MINDANAO, Surigao Province, *Bolster 364:* Cotabato District, *Clemens:* Davao District, *Warburg 14202.* SIBUTU, *Merrill 5293.* An Felsen und Bäumen oftmals am Meeresstrande.

UROSTACHYS BANAYANICUS Hert. sp. nov.

Radix fasciculata, 5 cm long. Frons griseo- vel brunneo-viridis, sexies-pluries bipartita, pendula, long. 100 cm et ultra, lat. 12–16 mm et ultra, foliis inclusis. Caulis subrigidus, postea flaccidus, basi diam. 2–3 mm foliis exclusis. Flores flaccidi, pluries bipartiti, long. 10–20 cm, lat. 1.5–2.5 mm. Folia sparsa, non densa, ± 6 pro cm, axim non tegentia, ± sexfaria, erecto-patentia, rarius horizontaliter patentia, tenera, lanceolata, acuminata, bruta, rarius nitida, plana, marginibus subrevolutis, (1–) 2–3 x 8–10 (–12) mm. Sporophylla densissima, lanceolata, erecto-patentia, saepe incurvata, seu appressa, ± quadrifaria, subcarinata, sporangia subtegentia, 1 x 2–3 mm. Sporangia lat. vix 1 mm. Planta epiphytica proxima *U. phlegmariae* a quo imprimis foliis angustis differt.—Non rara est forma monstrosa perfoliata (*)—Variat foliis tenerrimis habitu *U. pinifolii* (* *).

LUZON, Abra Province, *Bur. Sci. 7258 Ramos p.p.:* Bataan Province, Mount Mariveles, *Whitford 167*, Elmer 6826, Topping 845:* Laguna Province, Mount Banahao, *Calvin 325, For. Bur. 8003 Curran & Merritt, Bur. Sci. 879 Foxworthy.* MINDORO, Mount Halcon, *Merrill 6034, 6035.* PANAY, Antique Province. Culasi, *Bur. Sci. 32433 McGregor*.* NEGROS, Cuernos Mountains, *Elmer 9498.* CAMIGUIN DE MISAMIS, *Bur. Sci. 14840 Ramos.* MINDANAO, Davao District, *Copeland 1144*, 1450, Warburg 14201:* Agusan Province, Mount Urdaneta, *Elmer 13858**.* An Waldbäumen in Höhen von 1,000–2,000 m.

UROSTACHYS PHLEGMARIA (Linn.) Hert. comb. nov.

Lycopodium phlegmaria Linn. Sp. Pl. (1753) 1101, ed. 2 (1763) 1564.

Area geogr. Regn. paleotrop. Ins. Philipp.: *Cuming 1997 "Selaginella circinalis," 2002, 2007* Herb. Delessert. LUZON, Cagayan Province, Lallo, *For. Bur. 24849 Barros:* Tayabas Province, Mahaihai, *Brackenridge* in Wilkes U. S. Explor. Exped. 16 (1854) 326 ε *gracilescens*; Kabibihan, *Bur. Sci. 13001 Ramos:* Rizal Province, *Barthe:* Laguna Province, Siniloan, *Warburg 12938, 14022;* Mount Maquiling, *For. Bur. 26033 Mabesa;* Malinao, *Baker 3723:* Sorsogon Province, Mount Bulusan, *Elmer 15255.* POLILLO, *Bur. Sci. 9239 Robinson.* MIN-

DORO, Baco, *Merrill 885.* LEYTE, Dagami, *Wenzel.* PALAWAN, *For. Bur. 518 Curran.* SIARGAO, *Bur. Sci. 34985 Ramos & Pascasio.* MINDANAO, Agusan Province, *Weber 1179:* Lanao District, Lake Lanao, *Clemens.* An Bäumen in mittleren Höhen.

Nom. vulgare: Tagigongai (Neg.); tagalailai (Tag.).

UROSTACHYS SALVINIOIDES Hert. sp. nov.

Radix fasciculata, pluries bipartita, long. 3 cm. Frons griseo- v. luteo- v. brunneo-viridis, sexies s. magis bipartita, pendula, flaccida, long. 100 cm et ultra, lat. 8–12, rariter usque ad 15 cm foliis inclusis. Caulis flaccidus, basi diam. usque ad 1 mm foliis exclusis. Flores flaccidi, pluries bipartiti, long. 10–20 cm, lat. 1–1.5 mm. Folia subremota, ± sexfaria, 6–8 pro cm, axim non tegentia, tenera, horizontaliter s. erecto-patentia, ovata v. subcordata, acuminata, bruta v. nitida, plana, nervo vix prominente, 2–6 x 3–6 mm. Sporophylla conferta, ovato-lanceolata, erecto-incurvato-patentia s. appressa, ± quadrifaria, subcarinata, sporangia subtegentia, 1 x 2 mm. Spororangia lat. vix 1 mm. —Differt ab. *U. phlegmaria* foliis tenerrimis, horizontaliter patentibus, remotis, ovatis, paullummodo longioribus quam latis, ab. *U. nummulariifolio* et *U. Delbrückii* imprimis foliis acutiusculis.

Variat foliorum textura firmiore et teneriore.

Area geogr. Ins. Philipp. LUZON, Ifugao Subprovince, Mount Polis, *Phil. Pl. 1565 McGregor:* Apayao Subprovince, Mount Sulu, *Bur. Sci. 28379 Fénix:* Cagayan Province, *For. Bur. 16720 Curran:* Abra Province, *Bur. Sci. 7258 Ramos p.p.:* Bataan Province, Mount Mariveles, *Williams 786, For. Bur. 2101 Borden:* Laguna Province, San Antonio, *For. Bur. 9530, 13179 Curran, Bur. Sci. 20610 Ramos.* POLILLO, *Bur. Sci. 10292 McGregor.* CATANDUANES, *Bur. Sci. 30445 Ramos.* MINDORO, Binabay River, *Merrill 6036;* Baco River, *McGregor 294.* SAMAR, Catubig River, *Bur. Sci. 24396 Ramos.* PANAY, Capiz Province, *Bur. Sci. 30686, 31213 Ramos & Edaño, 35319 Martelino & Edaño.* LEYTE, Dagami, *Wenzel 274.* NEGROS, Mount Silay, *Whitford & Everett 1502;* Cuernos Mountains, *Elmer 9499.* MINDANAO, Zamboanga District, San Ramon, *Copeland 1450, Merrill 8298:* Lanao District, Camp Keithley, *Clemens:* Cotabato District, *Warburg 14198:* Davao District, Mount Apo, *Copeland 1274, Williams 2462, Elmer 10665.* JOLO, *Clemens 9368.* An Bäumen in mittleren und höheren Regionen.

Nom. vulgare: Nito-nito (Neg.).

Sectio NUMMULARIIFOLIURUS Hert. sect. nov.

Series NUMMULARIIFOLIA Hert. op. cit.

UROSTACHYS DELBRÜCKII Hert. sp. nov.

Radix fasciculata, pluries bipartita, long. 2 cm. Frons luteo-brunneo viridis, quinquies bipartita, pendula, flaccida, long. 35 cm, lat. 8–15 mm foliis inclusis. Caulis basi diam. 1 mm foliis exclusis. Flores simplices s. bipartiti, long. 10 cm, lat. 3–5 mm sporophyllis inclusis, subquadrifarii. Folia subconferta, quadrifaria-sexfaria, 6 pro cm, axim fere tegentia, erecto-patentia, subovata, obtusa s. subacuminata, subnitida, plana, marginibus subrevolutis, nervo infra prominente, subcoriacea, 3–4 x 6–8 mm. Sporophylla conferta, ± quadrifaria, lanceolata, acuminata, carinata, erecto-patentia, apice subrevoluta, sporangia subtegentia, 1.5 x 2.5 mm. Sporangia lat. ± 1 mm. Planta intermediaria inter *U. nummulariifolium* et species quasdam *Phlegmariuri* sectionis.

Area geogr. Ins. Philipp. MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4654 Mearns & Hutchinson.*

Genus **LYCOPODIUM** (Linn.) Hert. in Beih. Bot. Centralbl. (1922).

Lycopodium subgen. II–VI Hert. in Engl. Bot. Jahrb. 43 (1909) Beih. 98: 29.

Subgenus **Acrostachys** Hert. subgen. nov. Subgen. II–V Hert. l.c.

Sectio EULYCOPODIUM Hert. sect. nov. Subgen. II–III Hert. l.c.

LYCOPODIUM CLAVATUM Linn. Sp. Pl. (1753) 1100, ed. 2 (1763) 1564, var. **WALLICHIANUM** Spring Monog. Lycop. 1 (1842) 90.

Area geogr. Regn. subarct., temp., subtrop., trop. Ins. Philipp.: LUZON, Benguet Subprovince, *Callery 69,* Sablan, *Elmer 6257;* Baguio, *For. Bur. 964 Barnes, Topping 203;* Mount Santo Tomas, *For. Bur. 5002 Curran, 11096 Whitford, Merrill Phil. Pl. 964, Bur. Sci. 5351 Ramos;* Mount Ugo, *Bur. Sci. 5851 Ramos;* Pauai, *Topping 1144, Copeland 1946, Clemens 9114, Bur. Sci. 31903 Santos, 8445 McGregor:* Bontoc Subprovince, *Vanoverbergh 370:* Laguna Province, Mount Banahao, *Bur. Sci. 9844 Robinson.* An Felsenpartien oftmals in Graslandschaften, etc., in Höhen von 1,200–2,400 m.

LYCOPODIUM COMPLANATUM Linn. Sp. Pl. (1753) 1104, ed. 2 (1763) 1567.

Lycopodium anceps Wallroth; Schol. in Linnaea 14 (1840) 674, β *adpressifolium* Spring Monog. Lycopod. 1 (1842) 102. nebst forma *monostachya* (*).

Area geogr. Regn. subarct., temp., subtrop., trop. Ins. Philipp.: LUZON, Benguet Subprovince, Pauai, *Bur. Sci. 4232, 4465*

Mearns, 31902 Santos; Mount Tabiao, *Copeland 1813;* Mount Pulog, *For. Bur. 16324 Curran, Merritt, & Zschokke,*;* Baguio, *Elmer 6522;* Mount Tonglon (Santo Tomas), *Merrill Phil. Pl. 963, For. Bur. 5001 Curran, 11095 Whitford:* Bontoc Subprovince, Bauco, *Vanoverbergh 989:* Laguna Province, Mount Banahao, *For. Bur. 7982 Curran & Merritt, Bur. Sci. 2398 Foxworthy.* MINDORO, Mount Halcon, *Merrill 6033.* An freien Felsenabhängen, etc., in den höheren Gebirgen, in höhen von 1,650–2,400 m.

Nom. vulgare: Yoyokau (Ig.).

LYCOPODIUM SCARIOSUM Forst. Prodr. (1786) 86.

Area geogr. Australia, Nov. Zealand. Ins. Philipp.: MINDANAO, Davao District, Mount Apo, *Copeland 1041, 1451, Elmer 11384, DeVore & Hoover 339 p.p., 523 p.p.* In freien offnen Landschaften, auf dem Gebirgsrücken des Berges Apo, Höhe ungefähr 2,800 m.

Subgenus **Cernuostachys** Hert. op. cit.

LYCOPODIUM CERNUUM Linn. Sp. Pl. (1753) 1103 (Indiis) et ed. 2 (1763) 1566 [nebst γ *crassifolium* Spring Monog. Lycopod. 1 (1842) 80].

Area geogr. Regn. circumtrop. Ins. Philipp.: *Cuming 2020, 2335, Labillardière,* herb. Webb, herb. Paris. BATAN ISLANDS, Batan, *Bur. Sci. 3830 Fénix.* LUZON, *Jagor 760, 771:* Cagayan Province, Claveria, *Bur. Sci. 7568 Ramos:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19673 McGregor:* Benguet Subprovince, *For. Bur. 965 Barnes;* Sablan, *Bur. Sci. 12611 Fénix;* Mount Tonglon, *Bur. Sci. 5302, 5366 Ramos;* Pauai, *Bur. Sci. 31922 Santos;* Baguio, *Bur. Sci. 2475, 2758, 2840 Mearns, For. Bur. 4906 Curran, 972 Barnes, Topping 184, 3018, Elmer 5781:* Bontoc Subprovince, Bauco, *Vanoverbergh 51:* Lepanto Subprovince, Mount Malaya, *For. Bur. 16571 Darling;* Cervantes, *Bona 40:* Tayabas Province, *Bur. Sci. 26633, 28656 Ramos & Edaño, 9458 Robinson:* Laguna Province, *For. Bur. 19121 Tamesis, 9541 Curran, Bur. Sci. 15042 Ramos, Merrill Phil. Pl. 644, 957, Elmer 17874, Holman 32, 146, Baker 2348:* Bataan Province, Mount Mariveles, *For. Bur. 2096 Borden:* Zambales Province, Mount Pinatubo, *Bur. Sci. 2559, 2583 Foxworthy;* Nueva Vizcaya Province, Dupax-Carranglang Trail, *Bur. Sci. 14270 McGregor;* Imugan, *Bur. Sci. 14405 McGregor;* Santa Fé, *Bur. Sci. 8276 Ramos;* Caraballo Mountains, *Merrill 223:* Camarines Province, *For. Bur. 21684 Miranda, 27412 Alambra, Bur. Sci. 33624 Ramos & Edaño:* Albay Province, Mount Mayon, *Bur. Sci. 6494*

Robinson: Sorsogon Province, Mount Kililibong, *Bur. Sci. 23326 Ramos.* POLILLO, *Bur. Sci. 9094 Robinson, 10286 McGregor.* MINDORO, Bacubay, *For. Bur. 12106 Merritt;* Mount Halcon, *Merrill 6029, 6030* γ, *For. Bur. 4403 Merritt,* γ; Baco River, *McGregor 266, Merrill 4067.* PANAY, *Bur. Sci. 35703 Martelino & Edaño, 32298 McGregor.* LEYTE, Dagami, *Wenzel 75, 764, 1023.* NEGROS, Canlaon Volcano, *Merrill 6967, 8029* γ; Mount Silay, *Whitford & Everett 1529, For. Bur. 6226 Everett.* BUCAS GRANDE, *Bur. Sci. 35038 Ramos & Pascasio.* CAMIGUIN DE MISAMIS, *Bur. Sci. 14784 Ramos.* MINDANAO, Surigao Province, *Wenzel 1874, Bolster 304, Ballen 157;* Agusan Province, *For. Bur. 24507 Sabino, Elmer 14141:* Davao District, Mount Apo, *Elmer 10554, De Vore & Hoover 339 p.p., 523 p.p.* γ, *Copeland 1490* γ, *1038* γ; Lanao District, Camp Keithley, *Clemens 43, For. Bur. 20278 Miranda:* Misamis Province, Mount Malindang, *For. Bur. 4784 Mearns & Hutchinson:* Zamboanga District, San Ramon, *Copeland 1633, 1633a, 1768.* BASILAN, *Bur. Sci. 16229 Reillo.* An Felsenpartien und freien Abhängen, etc., meist in mittleren und höheren Regionen, selten in Meereshöhe, aufsteigend bis zu 2,800 m. Höhe.

Nom. vulgare: Duyoko (Ig.); kolo-kolo (Bon.); kuyo-kuyo (Bis.); lamong-babae (Tag.); lovi-lovi (Bik.); yakyakan (Ig.) yuyukau (Ig.).

LYCOPODIUM CASUARINOIDES Spring Monog. Lycopod. 1 (1842) 94.

Area geogr. As. merid. - or., Ins. Sund., Ins. Philipp.: *Cuming 2346.* LUZON, Benguet Subprovince, Loo, *For. Bur. 10944 Curran;* Pauai, *Bur. Sci. 4231, 4233 Mearns, Clemens 9229;* Baguio, *Topping 160, Elmer 6376:* Bontoc Subprovince, *Vanoverbergh 369.* MINDORO, Mount Halcon, *Merrill 6032.* An freien Gebirgskämmen und Felsenvorsprüngen, in Höhen von 1,400–2,400 m.

Nom. vulgare: Kulut-kulut (Bon.).

LYCOPODIUM VOLUBILE Forst. Prodr. (1786) 86.

Area geogr. Reg. Monsun., Ins. Societ., Nov. Zealand., Ins. Philipp.: LUZON, Benguet Subprovince, Mount Pulog, *Merrill 6392;* Mount Tonglon (Santo Tomas), *Merrill 4826, Topping 1208, Elmer 6240, For. Bur. 11102 Whitford, 4895 Curran;* Pauai, *Topping 1111, Bur. Sci. 4230 Mearns.* MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4628 Mearns & Hutchinson.* In dichtem Gebüsch auf Bergrücken in den höheren Gebirgen, in Höhen von 2,000–2,600 m.

Subgenus **Lateristachys** Hert. op. cit.

LYCOPODIUM HALCONENSE Copel. in Philip. Journ. Sci. 2 (1907) Bot. 149.

Area geogr. Ins. Philipp. MINDORO, Mount Halcon, *Merrill 6031*. Auf freien Berglehnen, in Höhen von 2,400 m.

DRITTER TEIL

ÜBERBLICK ÜBER DIE GEOGRAPHISCHE VERBREITUNG DER ARTEN

Auf den Philippinen sind durch die vorliegende Arbeit 22 Lycopodiaceen und zwar 15 *Urostachys*- und 7 *Lycopodium*-Arten nachgewiesen worden. Wie überall in den Tropen überwiegen auch auf den Philippinen die *Urostachya* bedeutend über die *Lycopodia.* Unter den Urostachyen sind die aufrechten Geophyten (Sect. *Selaginurus*) durch 2 Arten vertreten, während die hängenden Epiphyten mit 13 Arten (Sect. *Tenuistachys* mit 1 Art, *Squarrosurus* und *Carinaturus* mit je 3, *Phlegmariurus* mit 5 Arten, *Nummulariifoliurus* mit 1 Art) den Hauptbestandteil der Lycopodiaceenflora ausmachen. Unter den Lycopodien sind 3 kriechende *Eulycopodia,* ferner die 3 Hauptarten der tropischen Sect. *Cernuostachys* (1 Kriechstrauch, 2 Kletterer) sowie schliesslich 1 Art der interessanten Sect. *Lateralistachys* (Kriecher), deren übrige Arten auf das australe Florenreich beschränkt sind, vertreten.

Von den 22 philippinischen Lycopodiaceen sind 11 Arten, also die Hälfte, auch ausserhalb der Philippinen verbreitet, und zwar kommen 5 *Urostachya* und 6 *Lycopodia* auch ausserhalb des Gebietes vor, mithin fast alle Lycopodien, dagegen vehältnismässig wenige Urostachyen. Bis in das subarktische Gebiet hinein erstreckt sich das Areal von 2 Arten: *U. serratus* und *L. complanatum;* ersteres ist auf Ostasien beschränkt, letzteres ist über vier Erdteile verbreitet. Beide Arten kommen in unserem Gebiet nur auf den höchsten Gebirgen vor, während sie polwärts auch in der Ebene zu finden sind. Circumtropikal verbreitet sind 2 Arten: *L. clavatum* und *L. cernuum;* ersteres kann als Hochgebirgsform der in den subarktischen und temperierten Gebieten auch in der Ebene vorkommenden Hauptart aufgefasst werden, letzteres ist eine überall in den Tropen in allen Höhenlagen (im Hochgebirge in der Form γ *crassifolium*) häufige Species. Im palaeotropischen und australen Florenreich sind 3 Arten verbreitet: *U. carinatus* (As., Austral.), *U. phleg-*

Verbreitung der Philippinischen Lycopodien.

	Ausserhalb der Philippinen.					Auf den Philippinen.																	
	Reg. subarct. et temp.	Reg. subtrop. et trop.																					
		Reg. palaeo-trop.		Reg. neotrop.	Reg. austral.																		
		As.	Afr.			Bataan.	Babuyan (Camiguin).	Luzon.	Polillo.	Catanduanes.	Mindoro.	Samar.	Culion.	Panay.	Leyte.	Palawan.	Negros.	Siargao.	Bucas Grande.	Mindanao.	Basilan.	Jolo.	Sibutu.
Urostochys.																							
Ia 1. *minimus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
Ia 2. *serratus*	+	+	—	—	—	—	—	+	—	—	+	—	—	—	—	—	+	—	—	+	—	—	—
Ib 3. *verticillatus* γ & δ	+	—	—	—	—	—	—	+	—	—	+	—	—	—	—	—	—	—	—	+	—	—	—
Ic 4. *squarrosus*	—	+	+	—	—	—	+	+	—	—	+	—	—	+	—	—	+	—	—	+	—	—	—
Ic 5. *Magnusianus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
Ic 6. *Whitfordi*	—	—	—	—	—	—	—	—	—	—	+	—	—	+	+	—	—	—	—	+	—	—	—
7. *Toppingi*	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8. *carinatus*	—	+	—	—	+	—	—	+	+	—	—	—	—	—	—	—	—	—	—	+	—	—	—
9. *Merrilli*	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
IIa 10. *pinifolius*	—	+	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
IIa 11. *Elmeri*	—	—	—	—	—	—	—	+	—	—	+	—	+	—	—	+	—	—	—	+	—	—	+
IIa 12. *banayanicus*	—	—	—	—	—	—	+	+	—	—	+	—	—	+	—	—	+	—	—	+	—	—	—
IIa 13. *phlegmaria*	—	+	+	—	(+)	—	—	+	+	—	+	—	—	—	+	+	—	+	—	+	—	—	—
IIa 14. *salvinioides*	—	—	—	—	—	—	—	+	+	+	+	+	—	+	+	—	+	—	—	+	—	+	—
IIb 15. *Delbrückii*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
Lycopodium.																							
Ia 1. *clavatum* ε	(+)	+	+	+	+	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ia 2. *complanatum*	+	+	+	+	—	—	—	+	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—
Ia 3. *scariosum*	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—

Ib 4. *cernuum*	—	+	+	+	+	+	+	+	+	—	+	—	—	+	—	+	+	—	+	+	+	—	—
Ib 5. *casuarinoides*	—	+	—	—	—	—	—	+	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—
Ib 6. *volubile*	—	+	—	—	+	—	—	+	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
II 7. *halconense*	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—
Sa	2	10	5	3	5	2	3	16	4	1	12	1	1	5	3	3	5	1	1	16	1	1	1

maria (As., Afr., Austral.), *L. volubile* (As., Austral.). Auf das palaeotropische Florenreich beschränkt sind 3 Arten: *U. squarrosus* (As., Afr.), *U. pinifolius* (As.), *L. casuarinoides* As.). Dem australen Florenreich schliesslich gehört 1 Art an: *L. scariosum,* das im Gebiet auf dem höchsten Gipfel von Mindanao vorkommt. Von den 11 Endemismen, die sich aus 10 *Urostachys*-arten und 1 *Lycopodium* zusammensetzen, hat *U. minimus* (Gruppe des *U. selago*) seine nächsten verwandten in temperierten-subarktischen Gebieten bezw. auf den Hochgebirgen der Tropen, *L. halconense* (Gruppe des *L. laterale*) im australen Florenreich; ersteres kommt auf dem höchsten Gipfel von Mindanao, letzteres im Hochgebirge von Mindoro vor. Die übrigen 9 Endemismen haben ihre Verwandten in den umliegenden tropischen Gebieten wohnen. Es sind sämtlich hängende Epiphyten, die demnach den Hauptanteil auch unter den Endemismen ausmachen.

Die Lycopodiaceen der Philippinen zerfallen also in:

Drei Arten, die oder deren Verwandte bis in das subarktische Gebiet hinein verbreitet sind (die Geophyten *U. minimus, U. serratus, L. complanatum*).

Zwei circumtropikal verbreitete Arten (die Geophyten *L. clavatum* und L. *cernuum*).

Zwei Arten, die oder deren Verwandte im australen Florenreich zu Hause sind (die Geophyten *L. scariosum* und *L. halconense*).

Fünfzehn palaeotropische Arten, die zum kleinsten Teil auch im australen Florenreich verbreitet sind (alle epiphytischen *Urostachya* und die 2 kletternden *Lycopodia*).

Es sind im Gebiet der Philippinen bisher auf 18 Inseln Lycopodiaceen gefunden worden.

Die auch ausserhalb des Gebietes vorkommenden Arten.

	Inseln.
Urostachys serratus	4
Urostachys squarrosus	6
Urostachys carinatus	3
Urostachys pinifolius	3
Urostachys phlegmaria	7
Lycopodium clavatum ε	1
Lycopodium complanatum	2
Lycopodium scariosum	1
Lycopodium cernuum	11
Lycopodium casuarinoides	2
Lycopodium volubile	2
Sa.	42

Die endemischen Arten.

	Inseln.
Urostachys minimus	1
Urostachys verticillatus γ & δ	3
Urostachys Magnusianus	1
Urostachys Whitfordi	5
Urostachys Toppingi	1
Urostachys Merrilli	1
Urostachys Elmeri	6
Urostachys banayanicus	6
Urostachys salvinioides	10
Urostachys Delbrückii	1
Lycopodium halconense	1
Sa.	36

Am weitesten über das Inselreich verbreitet ist demnach von den ausserhalb des Gebietes vorkommenden Arten *L. cernuum* (auf 11 Inseln gefunden) und von den endemischen Arten *U. salvinioides* (auf 10 Inseln gefunden). Es folgen von den auch ausserhalb des Gebietes vorkommenden Arten: *U. phlegmaria* (auf 7 Inseln gefunden), *U. squarrosus* (6), *U. serratus* (4), *U. carinatus* und *U. pinifolius* (je 3), *L. complanatum, L. casuarinoides* und *L. volubile* (je 2), *L. clavatum* ϵ und *L. scariosum* (je 1); von den Endemismen: *U. Elmeri* und *banayanicus* (je 6), *Whitfordi* (5), *verticillatus* γ & δ (3), *minimus, Magnusianus, Toppingi, Merrilli, Delbrückii,* und *L. halconense* (je 1). In ihrer Gesamtheit sind also die endemischen Arten ähnlich über das Inselreich verbreitet wie die nicht endemischen, dagegen zeigt auch hier wieder die Gattung *Urostachys* eine weit grössere Verbreitung als die Gattung *Lycopodium.*

Alle Lycopodiaceen sind Gebirgspflanzen; nur wenige Arten gehen bis zum Meeresniveau hinab, so vor allem *U. squarrosus, U. salvinioides, U. Elmeri,* und *L. cernuum.* Infolgedessen sind die Hochgebirge der 3 grossen Inseln besonders reich an Lycopodiaceen. Es beherbergen:

	Arten.
Mindanao und Luzon, je	16
Mindoro	12
Panay und Negros, je	5
Polillo	4
Camiguin, Leyte, and Palawan, je	3
Batan	2
Die übrigen Inseln, je	1

Auf Mindanao beschränkt sind 4 Arten (3 endemische: *U. minimum, U. Magnusianus,* und *U. Delbrückii,* sowie 1 Art die sonst nur im australen Florenreich vorkommt, *L. scariosum*).

Auf Luzon beschränkt sind 3 Arten (2 endemische: *U. Toppingi, U. Merrilli,* ferner 1 Hochgebirgsart der Tropen, *L. clavatum* ε).

Auf Mindoro beschränkt ist die einer australischen Untergattung angehörende Art, *L. halconense.*

Wichtige Zentren sind:

Mindanao: Davao Distr., Todaya (Mount Apo) und Misamis Prov., Mount Malindang, 2,000–3,200 m, mit den 11 Arten: *U. minimus, serratus, verticillatus* γ & δ, *squarrosus, pinifolius, banayanicus, salvinioides, Delbrückii, L. scariosum, cernuum, volubile.*

Luzon,[1] Mountain Prov., Benguet Subprov., Mount Tonglon (Mount Sto. Tomas), Pauai, etc., 2,000–2,400 m, mit den 8 Arten: *U. serratus,* **Merrilli,** *pinifolius, L.* **clavatum, complanatum,** *cernuum,* **casuarinoides,** *volubile.*

Mindoro,[1] Mount Halcon, 2,000–2,700 m, mit den 8 Arten: *U. serratus, verticillatus* γ & δ, *squarrosus, banayanicus, L.* **complanatum,** *cernuum,* **casuarinoides, halconense.**

An diesen 3 Standorten kommen also insgesamt 16 Arten vor, von denen ein grosser Teil—mit Ausnahme besonders der oben genannten 4 bis zum Meere herabgehenden Arten *U. squarrosus, U. salvinioides, U. Elmeri,* und *L. cernuum*—auf den 3 Hauptinseln beschränkt ist. Die 6 Arten: *U. Magnusianus, U. Whitfordi, U. Toppingi, U. carinatus, U. Elmeri, U. phlegmaria,* bevorzugen anscheinend mittlere und niedere Gebirgslagen. Die Mehrzahl dieser Arten kommt—ebenso wie die genannten 3 bis zum Meeresspiegel gehenden Arten—auch auf den kleineren Inseln vor.

[1] Die auf Mindanao nicht vorkommenden Arten sind fett gedruckt.

THE ANTISCORBUTIC VITAMINE IN SOME ORIENTAL FRUITS AND VEGETABLES [1]

By HARTLEY EMBREY

Of the Union Medical College, Peking

FIVE PLATES

Less is known of the antiscorbutic vitamine than of the other vitamines. It is soluble in water, and for that reason is often called water-soluble C vitamine. It is also soluble in alcohol and acetone.

It is more unstable than the other vitamines and is destroyed by heat—gradually above 50°C. and rapidly above 80°C. (1) It is also affected by catalysis. (2) For instance, if half of a given quantity of raw milk be heated in a glass vessel and the other half in a copper vessel for the same length of time—for thirty minutes at 145°F.—the milk heated in the copper vessel will have lost much more of the antiscorbutic vitamine than the milk heated in the glass vessel.

This vitamine is very unstable in the presence of alkalies and is especially sensitive to oxidation. In fact, oxidation is apparently the preëminent factor leading to the destruction of water-soluble C vitamine.

If a diet be given containing an insufficient amount of this vitamine, scurvy develops. This disease can be cured by the addition to the diet of fresh fruits and vegetables, which are rich in the antiscorbutic vitamine.

This paper discusses some research work that was undertaken with the hope of extending our knowledge as to which tropical fruits and foods are valuable as sources of supply of the antiscorbutic vitamine.

None of the vitamines can be determined satisfactorily by chemical means. Their presence can be detected and their relative quantities estimated by feeding experiments only. The guinea pig is very susceptible to scurvy and, therefore, is the best experimental animal for this purpose. Fed on a diet com-

[1] From the laboratories of Union Medical College, Peking; and the Bureau of Science, Manila, Philippine Islands.

plete in all other respects, but lacking in this one essential, the guinea pig develops scurvy as early as the fifteenth day and death occurs, usually, on the nineteenth to the twenty-third day.

The clinical symptoms of scurvy in the guinea pig are the following: Preliminary loss of weight, swelling of wrist and knee joints, and occasionally hyperæmia of the gums with dullness of the lower incisors. Fractures of the long bones and general fragility are common. Post-mortem examination shows "hemorrhages found in the muscles, bone marrow, more frequently at the end of diaphyses, tooth pulp, costochondral junctions, and occasionally in the skin and lymph glands; enlargements of the ends of the long bones, especially the lower ends of the radius and ulna, the upper end of the tibia, and the costochondral junctions; and swollen lymph glands especially the inguinal and axillary."(3)

The following fruits and vegetables were tested at the Bureau of Science in Manila:

Chico, *Achras sapota* Linnæus.
Papaya, *Carica papaya* Linnæus.
Pomelo, *Citrus maxima* Merrill.
Guava, *Psidium guajava* Linnæus.
Lansones, *Lansium domesticum* Correa.
Banana, *Musa cavendishii* Lambert.
Banana flower bud.
Coconut, *Cocos nucifera* Linnæus.
Pepino or cucumber, *Cucumis sativas* Linnæus.
Kangkong leaves, *Ipomoea reptans* (Linnæus) Poiret.
Camote leaves, *Ipomoea batatas* (Linnæus) Poiret.

In addition to the fruits tested at the Bureau of Science in Manila, another fruit, the Chinese persimmon, *Diospyros kaki* Linnæus, was tested at the Union Medical College, in Peking, China.

Filipinos usually cook the camote and kangkong leaves and use them as greens. The banana-flower bud is boiled and used as a vegetable by most Filipinos, and to a limited degree by foreigners as well. In our feeding experiment, however, we cut the camote and kangkong leaves fine and gave them raw. In the case of the banana-flower bud and of the coconut, we expressed the juice and fed the undiluted juice, since the guinea pigs would not eat either the bud or the shredded coconut meat. The other foods were given in their raw, natural state.

For all the foods except persimmon, basal diet 1 was used, which consisted of:

	Per cent.
Whole oats	87
Rice bran (tikitiki)	10
Calcium chloride and disodium orthophosphate (equal weights)	3

The mixture of the above was given ad libitum; and, in addition, 30 cubic centimeters of whole cow's milk, previously boiled forty-five minutes, were given daily.

For the persimmon, basal diet 2 was used, which consisted of:

	Per cent.
Whole wheat	86
Yeast	2
Wheat bran	3
Butter	3
Calcium lactate	3
Sodium chloride	3

In the case of control guinea pig 3P, orange juice was added and the scurvy symptoms disappeared. Each animal was kept in a separate cage. Each morning all remains of the basal diet for the preceding day were removed, and a weighed amount of the food under examination was put in the cage. After a few hours, if the food was not eaten, it was fed to the guinea pig by hand; then the basal diet was given ad libitum. The guinea pigs were weighed twice a week, and a record of their weights was kept. Autopsy was performed on all guinea pigs that died before the termination of the experiment, to see whether the typical scurvy symptoms were present. The experiment in Manila was unfortunately of only nine weeks' duration, and it would be advisable to continue this work in order to determine the minimum amount of each food that must be administered daily to afford complete protection from scurvy. A group of control guinea pigs was given the basal diets without any fresh fruit or vegetable.

The Chinese persimmon was fed at the Union Medical College, Peking, and the experiment lasted twenty-four weeks.

CONCLUSIONS

1. All of the control guinea pigs died of acute scurvy in from nineteen to twenty-one days.

2. Of the foods examined, pomelo, cucumber, chico, and guava afforded the best protection from scurvy. In each case 10 grams of the food given daily were sufficient to protect the

animals from scurvy for a period of nine weeks. Where the charts show deaths on these diets after a few weeks, post-mortem examination showed the causative factor to be pneumonia.

3. Fifteen grams of banana each day gave protection from scurvy for a period of nine weeks.

4. The experiment with lansones had to be terminated after four weeks, because this fruit disappeared from the Manila markets, being no longer in season. A careful inspection of the lansones growth curves shows a steadily decreasing weight, so that 10 grams were evidently insufficient as a protection from scurvy.

5. Fifteen grams each of kangkong leaves and of camote leaves daily gave protection for a period of from seven to nine weeks.

ACKNOWLEDGMENT

Thanks are due to Miss Sylvia Sleeper, of Manila, and to Mr. Tsan Ching Wang, of Peking, who rendered valuable technical assistance.

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ILLUSTRATIONS

EXPLANATION OF CHARTS

The following charts show the identification numbers of the guinea pigs, the rates of growth, and the number of weeks' duration of experimental feeding.

The numbers above the growth curves are the identification numbers of the animals; the weights of the guinea pigs are shown by the figures on the axes of ordinates; the number of weeks of experimentation is indicated by the numbers on the axes of abscissæ. An arrowhead terminating the growth curve indicates the death of the animal in question. If the arrowhead is lacking, the animal was still living at the end of the experiment.

Guinea pigs 45, 46, 47, 48, 49, 50, 7, 13, 14, 15, 16, 21, 22, 23, 24, 34, 36, 37, 39, 41, 43, 44, 1P, 2P, 4P, 5P, 6P, 7P, and 8P died of scurvy. Deaths among the other pigs were due to pneumonia.

Basal diet 1 consisted of whole oats, 87 per cent; rice bran (tikitiki), 10 per cent; calcium carbonate ($CaCO_3$) and disodium orthophosphate (Na_2HPO_3), 3 per cent.

Basal diet 2 consisted of whole wheat, 86 per cent; yeast, 2 per cent; wheat bran, 3 per cent; butter, 3 per cent; calcium lactate, 3 per cent; sodium chloride, 3 per cent.

PLATE 1

FIG. 1. Guinea pigs 45 to 50. Diet, 30 cubic centimeters of whole milk boiled for forty-five minutes and basal diet 1.
2. Guinea pigs 17 to 20. Diet, 10 grams of raw chico and basal diet 1.
3. Guinea pigs 9 to 12. Diet, 10 grams of raw guava and basal diet 1.

PLATE 2

FIG. 4. Guinea pigs 5 to 8. Diet, 10 grams of raw lansones and basal diet 1.
5. Guinea pigs 25 to 28. Diet, 15 grams of raw banana and basal diet 1.
6. Guinea pigs 13 to 16. Diet, 10 cubic centimeters of banana flower bud juice and basal diet 1.

PLATE 3

FIG. 7. Guinea pigs 21 to 24. Diet, 10 cubic centimeters of fresh coconut juice squeezed from the white coconut meat and basal diet 1.
8. Guinea pigs 1 to 4. Diet, 10 grams of raw papaya and basal diet 1.
9. Guinea pigs 29 to 32. Diet, 10 grams of fresh raw pomelo and basal diet 1.

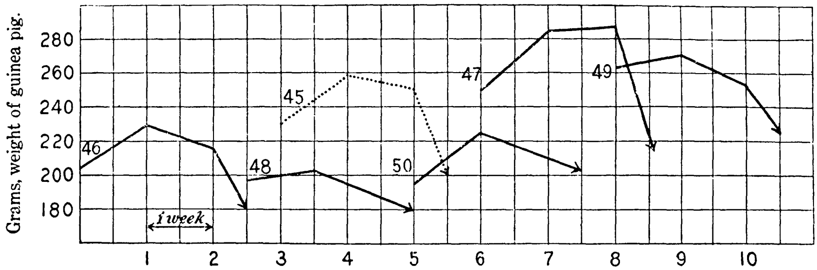
PLATE 4

10. Guinea pigs 33 to 36. Diet, 10 grams of raw pepino and basal diet 1.

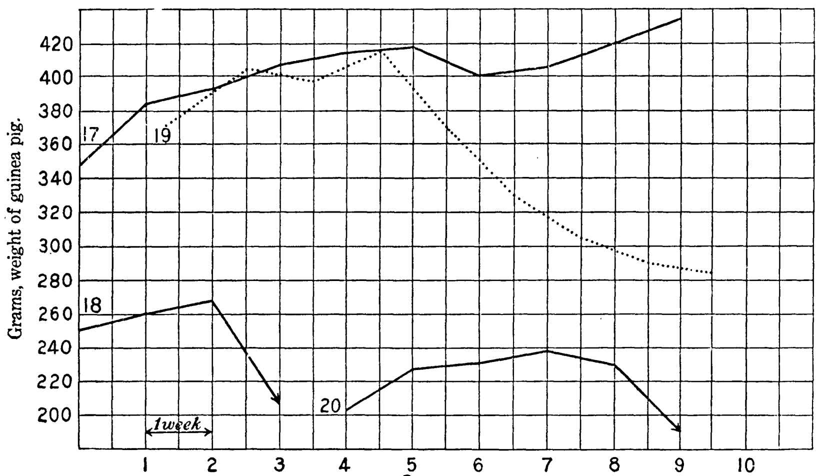
11. Guinea pigs 37 to 40. Diet 15 grams of raw camote leaves and basal diet 1.
12. Guinea pigs 41 to 44. Diet, 15 grams of raw kangkong leaves and basal diet 1.

PLATE 5

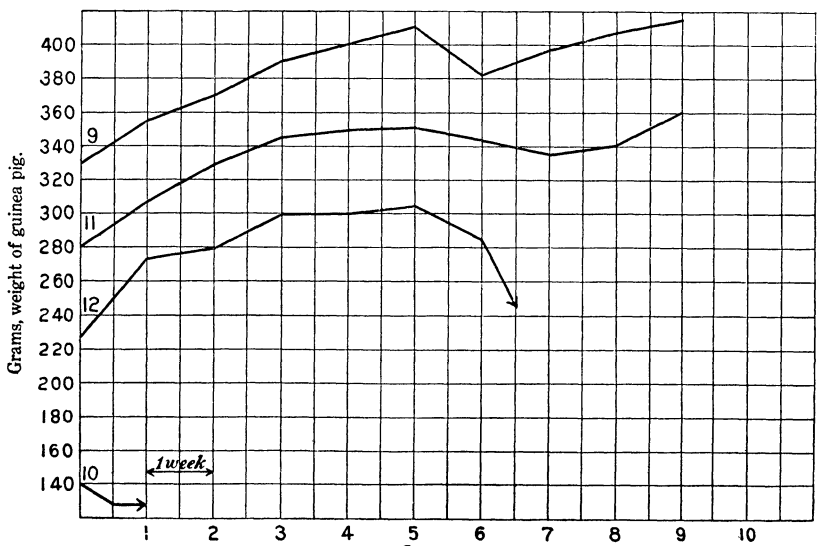
FIG. 13. Guinea pigs 1P to 4P. Diet, 300 cubic centimeters of whole milk previously boiled for forty-five minutes, ad libitum, and basal diet 2.
14. Guinea pigs 5P to 8P. Diet, 25 grams of fresh raw persimmon daily and basal diet 2, ad libitum.
15. Guinea pigs 9P to 12P. Diet, 30 grams of fresh raw persimmon daily and basal diet 2.


Grams, weight of guinea pig.
1 week
46
48
45
50
47
49

1

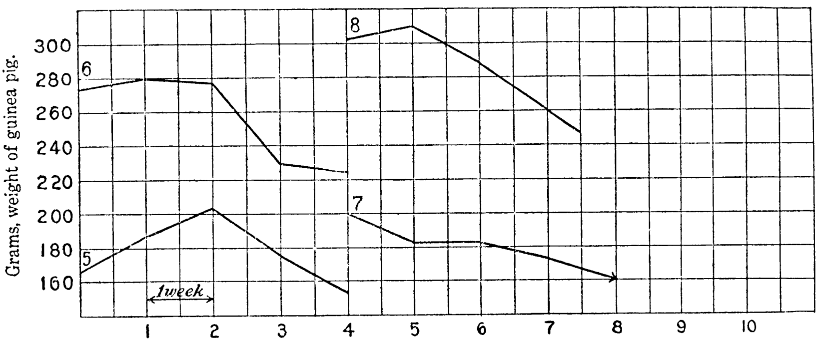

Grams, weight of guinea pig.
1 week
17
19
18
20

2

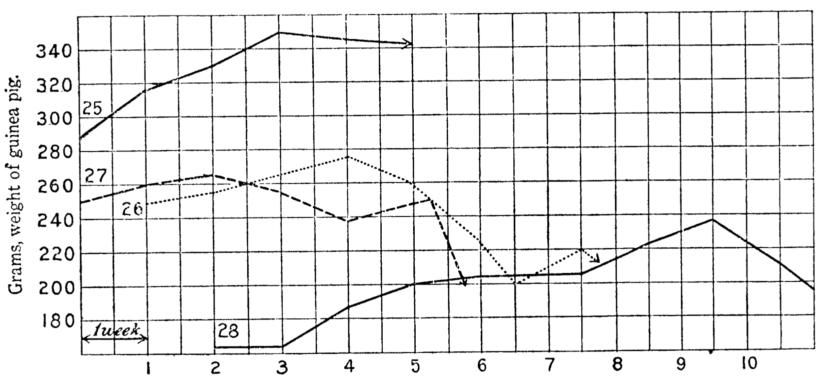

Grams, weight of guinea pig.
1 week
9
11
12
10

3

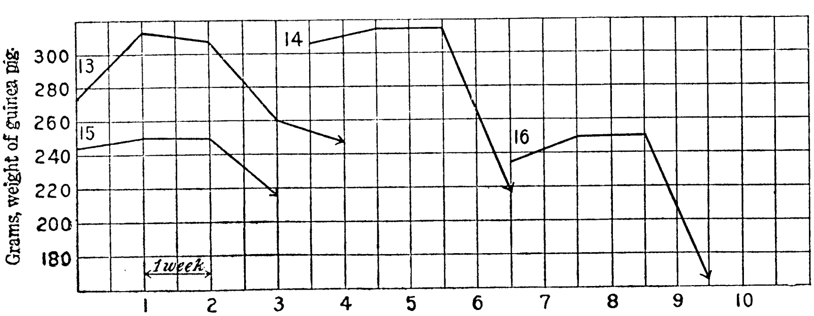
PLATE 1.


Grams, weight of guinea pig.
300
280
260
240
220
200
180
160
1 week
1 2 3 4 5 6 7 8 9 10
5
6
7
8

4

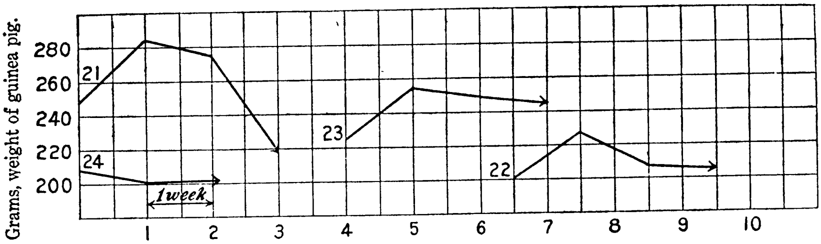

Grams, weight of guinea pig.
340
320
300
280
260
240
220
200
180
1 week
1 2 3 4 5 6 7 8 9 10
25
26
27
28

5

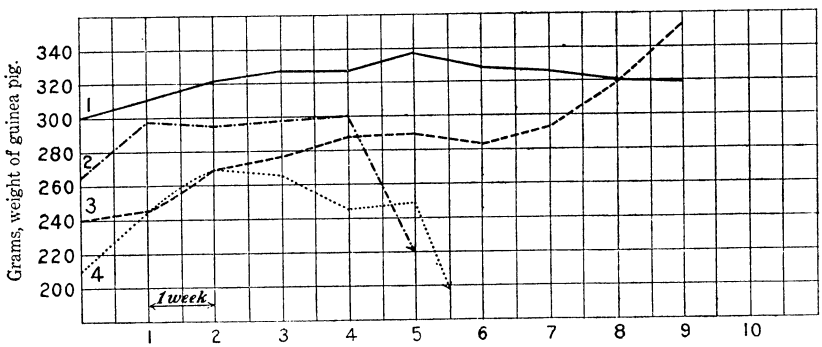

Grams, weight of guinea pig.
300
280
260
240
220
200
180
1 week
1 2 3 4 5 6 7 8 9 10
13
14
15
16

6

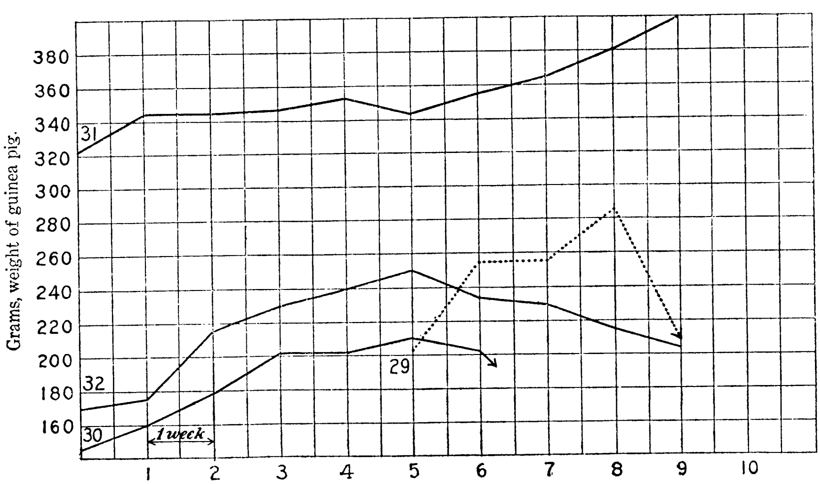
PLATE 2.


Grams, weight of guinea pig.
280
260
240
220
200
21
24
23
22
1 week
1 2 3 4 5 6 7 8 9 10

7

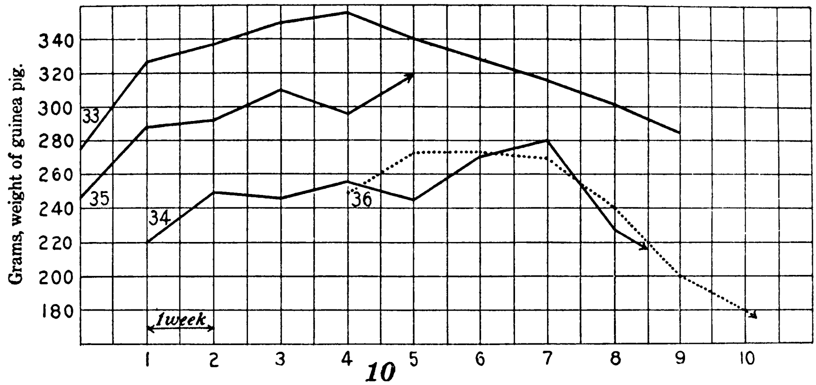

Grams, weight of guinea pig.
340
320
300
280
260
240
220
200
1
2
3
4
1 week
1 2 3 4 5 6 7 8 9 10

8


Grams, weight of guinea pig.
380
360
340
320
300
280
260
240
220
200
180
160
31
32
30
29
1 week
1 2 3 4 5 6 7 8 9 10

9

PLATE 3.



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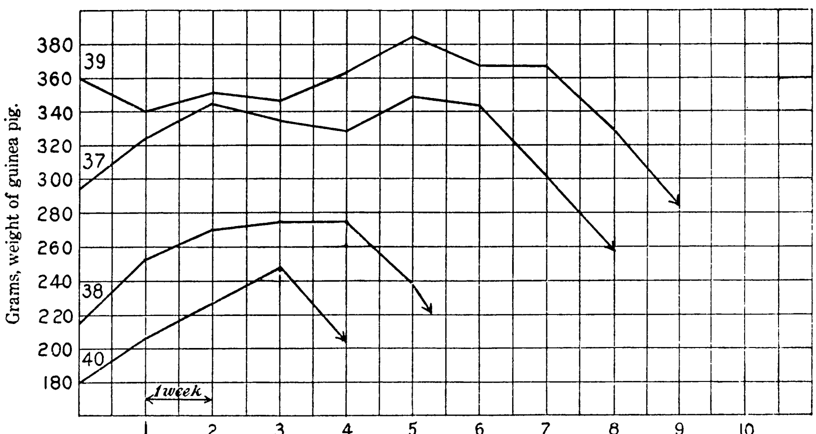

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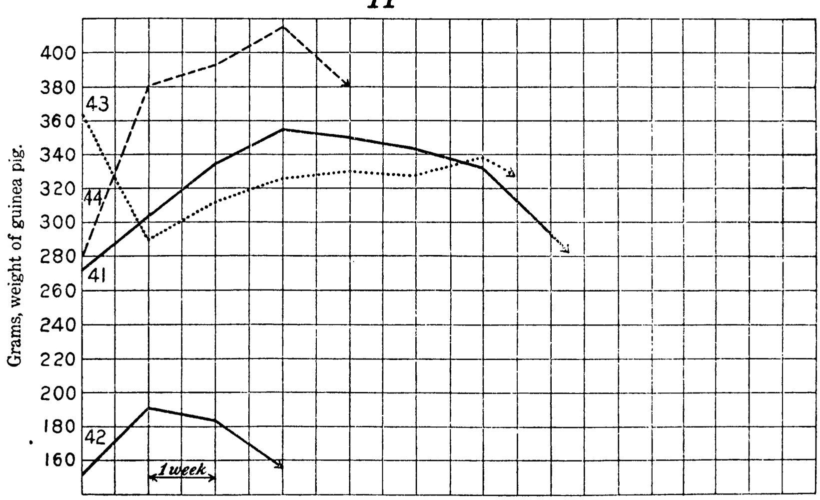

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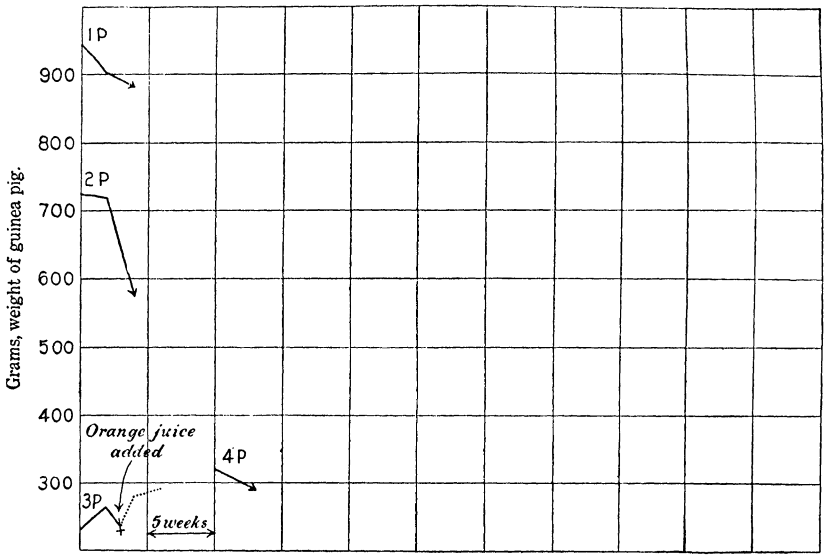
PLATE 4.



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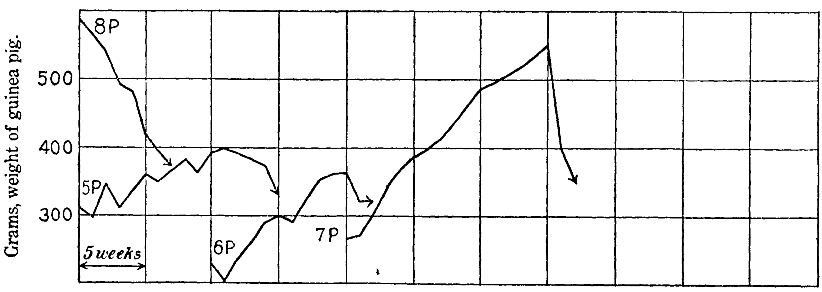

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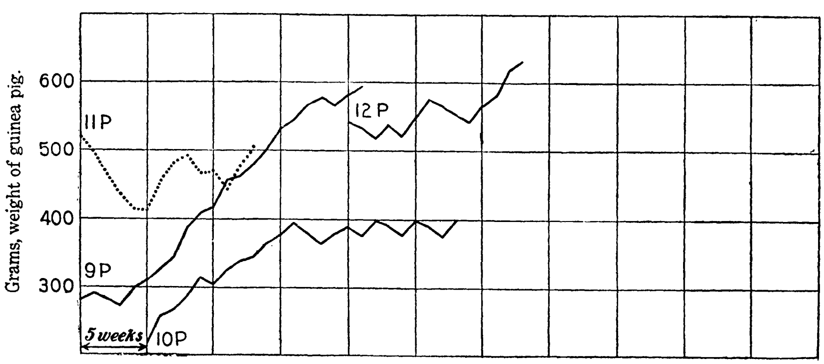

15

PLATE 5.

THE ELACATIDÆ OF THE PHILIPPINE ISLANDS AND ADJACENT REGIONS

By EDWARD A. CHAPIN

Of Washington, D. C.

ONE PLATE

The material upon which this paper is based was received at various times from Prof. Charles F. Baker, of the University of the Philippines. The family has been considered as composed of a single genus, since *Ababa* Casey was referred by Schaeffer (1917) to the family Cleridæ. Several species of the family Elacatidæ are known from the New World; two from Japan and one each from Batjan, Ceylon, and Borneo. The family is usually known under the name of Othniidæ, based on *Othnius* Leconte. *Elacatis* Pascoe has priority of a year.

The type genus, *Elacatis* Pascoe, was erected in 1860 as a member of the Melandryidæ to include a single species of doubtful affinities. The following year Leconte proposed a new family, the Othniidæ, for an American insect, *Othnius umbrosus,* a new genus and new species. A second species was mentioned at the time, but was described from memory only, the specimen being lost. Thus *O. umbrosus* Leconte is the type of *Othnius. Elacatis* Pascoe has been suppressed as a homonym of *Elacates* Cuvier, 1829, and *Othnius* Leconte has taken its place in most of the catalogues. This action was not taken by Kraatz or Lewis but was resumed by Borchmann.[1] A hasty examination of one of the American species revealed certain characters that may be considered of generic value; if such is the case, *Othnius* Leconte will stand for the New World forms.

ELACATIDÆ

Family characters.—Coleoptera genuina; Heteromera; head somewhat triangular, eyes large and prominent, lateral; labrum corneous, antennæ 11-segmented, arising from beneath the prominent supra-antennal crests, first segment moderately long and thick, second smaller, globular or cylindrical, third

[1] Schenkling, S., Col. Cat. Fam. Pars. 2, Othniidæ (1910).

to eighth inclusive cylindrical, ninth to eleventh considerably wider, forming a loose club. Mandibles stout and curved. Mentum of males of some species with two tufts of hairs arising within foveæ, of females with two foveæ. Thorax transverse, margins even or denticulate, anterior angles variable, anterior coxal cavities small, closed behind. Abdomen with five visible ventral segments, the first longer than any of the succeeding. Legs not long, rather stout, claws simple.

Type genus, *Elacatis* Pascoe, 1860.

The material considered in this paper falls into two genera, which may be distinguished inter se by the following characters:

Eyes evenly rounded before and behind, anterior angles of thorax not covered by the eyes, lateral margin of the thorax with denticles.
Elacatis Pascoe.

Eyes developed posteriorly so that they overlie the anterior angles of the thorax, lateral margin of thorax without denticles.
Parelacatis g. nov.

Genus ELACATIS Pascoe

Elacatis PASCOE, 1860, Journ. Ent. 1 (1860) 52; LEWIS, Ent. Mo. Mag. 27 (1891) 248.

Generic characters.—Elacatidæ with eyes anteroposteriorly symmetrical, lateral margin of thorax with three to seven denticles, second segment of antenna globular, terminal segment of labial palpus sharply truncate, terminal segment of maxillary palpus twice as long as broad (Plate 1, figs. 1, 2, 5, 6, 7).

Genotype, *Elacatis delusa* Pascoe.

There are three species belonging to this genus before me, which may be distinguished as follows:

1. Middle portion of prosternum with a few indistinct punctures, lateral portions with punctures somewhat confused............ **E. bakeri** sp. nov.
   Prosternum evenly, coarsely punctured............ 2.
2. Pronotum with a median smooth line, rest of surface finely punctured.
   E. undulata sp. nov. cum subsp. nov.
   Pronotum evenly, very coarsely punctured, no median smooth line.
   E. delusa Pascoe cum subsp. nov.

Elacatis bakeri sp. nov.

Head finely and densely punctured, eyes finely granulate; somewhat brassy above, piceous beneath; mentum bifoveate, antennæ piceous, reaching just beyond anterior margin of thorax; thorax broader than long (7 : 10), convex, lateral margins low on sides with four very feeble denticles, surface densely and rather coarsely punctured, dark piceous with brassy luster, scutellum small, elytra tapering evenly to tips, rather more

finely but not as densely punctured as thorax, pale brown with piceous markings. These markings consist of a round spot in the scutellar angle, a larger round spot slightly postmedian on the suture, common to both, a broken fascia at apical fifth, and the lateral margins narrowly. Underparts almost black, finely punctured, legs dark, tibiæ and tarsi lighter. Length, 3.7 millimeters.

Type.—A specimen, apparently a female, from Penang, (*C. F. Baker*); United States National Museum, No. 25054.

Elacatis undulata sp. nov.

Head distinctly evenly and moderately coarsely punctured, the punctures near the labrum finer than those on frons, foveæ on mentum large, almost contiguous, surface above with bright brassy luster. Antennæ reaching about the middle of thorax, basal segments pale. Thorax with median smooth line, otherwise rather finely and densely punctured. Lateral margin with four obtuse denticles, luster brassy. Elytra rather long and narrow, finely and evenly punctured, ornamental with a very intricate dark and light pattern (Plate 1, fig. 11). Underparts of thorax nearly black, the abdomen chestnut brown, finely and evenly punctured. Legs chestnut brown, indistinctly ringed with piceous.

This species appears to be separable into two subspecies. Typical form: Punctures of thorax coarser, dark markings of elytra well developed, pygidium rather densely covered with long pale hairs. Length, 4 millimeters.

Type.—A male from Mount Limay, Bataan Province, Luzon, P. I. (*Baker*); paratypes, three specimens from the same place; United States National Museum, No. 25056.

Elacatis undulata subsp. **bornensis** subsp. nov.

Thoracic punctures not at all confused, dark markings of elytra reduced in extent, pygidium with few short hairs. Length, 4.5 millimeters.

Type.—A specimen, apparently a male, from Sandakan, Borneo (*Baker*); United States National Museum, No. 25058.

In this species the foveæ of the mentum in the males do not have the tufts of hairs sometimes found in the genus.

Elacatis delusa Pascoe.

Elacatis delusa PASCOE, Journ. Ent. 1 (1860) 53, pl. 2, fig. 5.

Head rather coarsely and not densely punctured, antennæ reaching to middle of thorax, color dark with slight brassy

luster. Thorax apparently as long as broad, very coarsely and evenly punctured, lateral margins with five denticles. Elytra evenly punctured, variegated with dark and light brown. Underparts dark, rather coarsely punctured. Legs dark.

Two subspecies can be recognized in the material at my disposal. Typical form: Elytra with three transverse dark bars and with a round dark spot in scutellar angle. Length, 3.5 millimeters.

Sandakan, Borneo (*Baker 11493*) and unnumbered specimens. Zamboanga, Mindanao, P. I. (*Baker 7283*).

Elacatis delusa subsp. **pantherina** subsp. nov.

Elytra with four more or less broken transverse dark bars (Plate 1, fig. 12), no separate spot in scutellar angle. Denticles of thorax slightly more prominent. Length, 3.5 millimeters.

Type.—A specimen, apparently a male, from Mount Limay, Bataan Province, Luzon, P. I. (*Baker 8292*). Paratypes from the same locality and from Mount Maquiling, Laguna Province, Luzon (*Baker 11941*). Also unnumbered specimens from the above localities. United States National Museum, No. 25055.

Genus PARELACATIS novum

Generic characters.—Elacatidæ with eyes produced posteriorly so as to overlap anterior angles of thorax; thorax with lateral margin more or less obsolete at anterior angles, complete at posterior angles, regular, without denticles. Second segment of antenna cylindrical, terminal segment of labial palpus rounded at apex, terminal segment of maxillary palpus only a little longer than broad (Plate 1, figs. 3, 4, 8, 9, 10).

Genotype, *Parelacatis bakeri* sp. nov.

There appears to be but one species in the material before me that can be referred to this genus.

Parelacatis bakeri sp. nov.

Head wide, convex, rather coarsely and distantly punctured, dark, with faint brassy luster. Supra-antennal crests arched, socket of antenna very large. Antennæ reaching to about middle of thorax, chestnut brown. Thorax much broader than long (13 : 20), convex, evenly and rather coarsely punctured, basal angles obtuse, surface with brassy luster, pubescence sparse on both head and thorax. Elytra rather suddenly rounded at tips, finely and rather densely punctured, dark with pale marking (Plate 1, fig. 13). Underparts black, rather more densely covered with hairs. Legs brown, the tibiæ and tarsi paler. Length, 2.5 to 3.5 millimeters.

Type.—A specimen, sex uncertain, from Basilan, P. I. (*Baker 13420*). Paratypes from the same locality and from Davao, Mindanao (*Baker 6659*); Iligan, Kolambugan, and Dapitan, Mindanao; Tangcolan, Bukidnon Province, Mindanao (*Baker 14665*); Mount Maquiling and Los Baños, Laguna Province, Luzon (*Baker 958*). United States National Museum, No. 25057.

ADDENDA

Since I sent this manuscript for publication, a paper by F. Borchmann [2] on the "Othniidæ" of the world has come to hand. Borchmann has prepared a very excellent study of the group, and if he has erred it has been on the side of conservatism. In his work a new species, *Othnius corporaali*, is described with the note that it may belong to a new genus. It appears to be congeneric with *Parelacatis bakeri* sp. nov., the type of my new genus *Parelacatis*. *Othnius acutedentatus*, a new species, is reported from Borneo and Luzon and would have been treated by me as a subspecies of *Elacatis delusa* Pascoe, so far as I am able to judge from the description. The same is true of his *Othnius foveicollis*. Borchmann [3] has described another species from northern Palawan under the name *Othnius ochripes*. It is unknown to me.

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[2] Arch. f. Naturg. 87 (1921) Abt. A, Heft 1, 191–215.
[3] Ent. Mitteil. 10 (1921) 198.

ILLUSTRATION

[From drawings by Chapin.]

PLATE 1

FIG. 1. *Elacatis delusa* subsp. *pantherina* subsp. nov., head.
2. *Elacatis delusa* subsp. *pantherina* subsp. nov., thorax from beneath.
3. *Parelacatis bakeri* sp. nov., head.
4. *Parelacatis bakeri* sp. nov., thorax from beneath.
5. *Elacatis delusa* subsp. *pantherina* subsp. nov., antenna.
6. *Elacatis delusa* subsp. *pantherina* subsp. nov., maxilla.
7. *Elacatis delusa* subsp. *pantherina* subsp. nov., labium with palpi.
8. *Parelacatis bakeri* sp. nov., labium with palpi.
9. *Parelacatis bakeri* sp. nov., maxilla.
10. *Parelacatis bakeri* sp. nov., antenna.
11. *Elacatis undulata* sp. nov., elytron.
12. *Elacatis delusa* subsp. *pantherina* subsp. nov., elytron.
13. *Parelacatis bakeri* sp. nov., elytron.

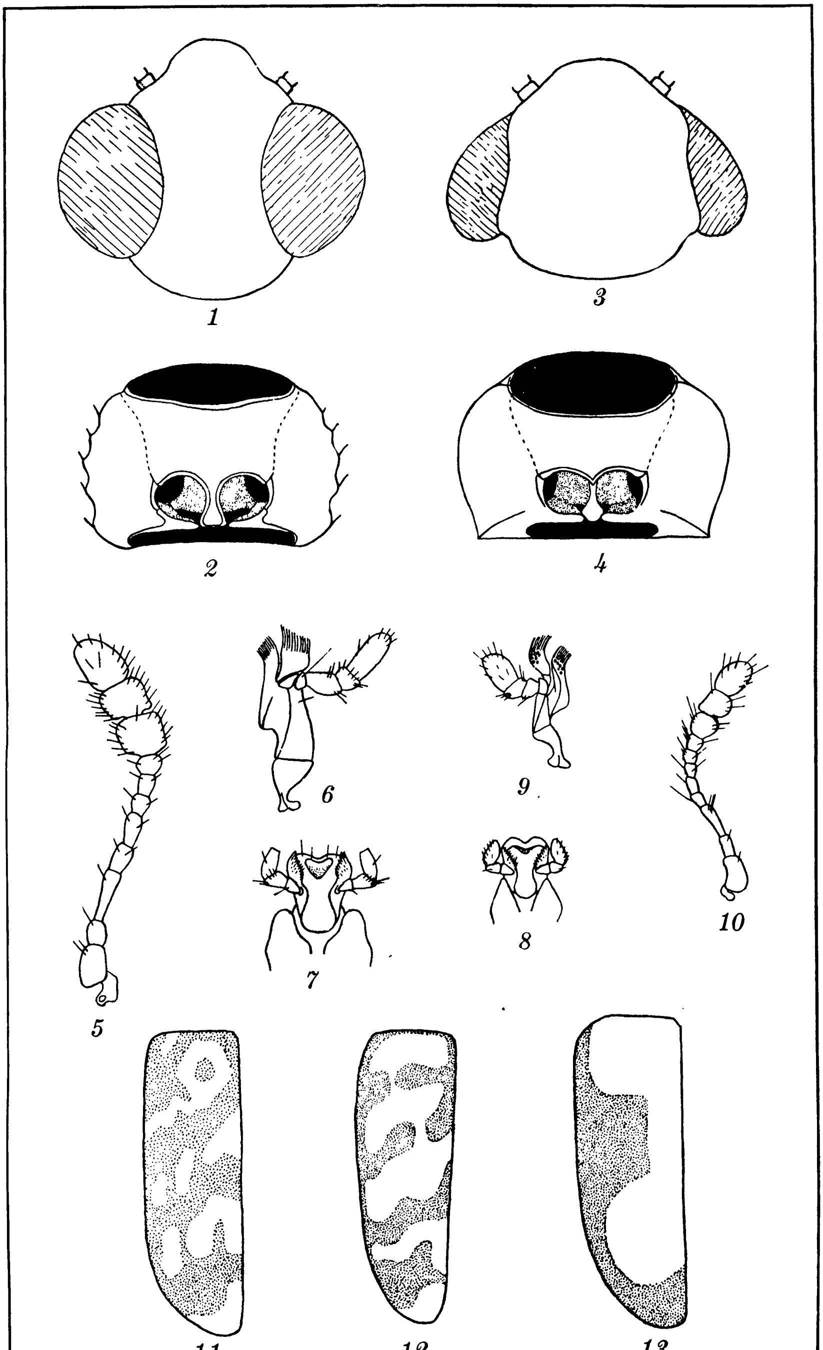

PLATE 1.

ZUR GEOGRAPHISCHEN VERBREITUNG DER CUCUJIDÆ (COLEOPTERA)[1]

ERSTER BEITRAG: LÆMOPHLŒINI

Von Fritz Kessel

Badenfurt, Süd-Brasilien

EINE TEXTFIGUR

Ueber den Cucujiden ist in den letzten Jahrzehnten intensiv gearbeitet worden. Besonders Grouvelle hat seit Mitte der siebziger Jahre des vorigen Jahrhunderts sehr viel publiziert; nächst ihm Sharp, Reitter, and andere. Leider fehlt es aber bisher fast durchweg an irgendwelchen zusammenfassenden Arbeiten über diese Familie beziehungsweise grössere Gruppen derselben. Das Material ist in den Zeitschriften fast aller Herrenländer verteilt, zerstreut sich auf grössere Zeiträume, sodass eine einigermassen umfassende Arbeit nicht unerhebliche Schwierigkeiten zu überwinden hat.

Von einzelnen Gruppen der Cucujiden hat, soweit mir bekannt, Grouvelle bis 1914 die Silvaninen und Ancistriinen zusammenhängend dargestellt. Ich nehme die Cucujidæ und Læmophlœini zunächst noch ohne Rücksicht auf meine früheren Ausführungen.[2]

Gerade die Zahl der bekannten Læmophlœinen-Arten ist riesig gewachsen. Der Katalog von Gemminger und Harold (1868) zählt 51 Arten; mir sind bis heute schon über 220 Arten bekannt geworden, und mit dieser Zahl dürfte auch noch nicht das letzte Wort gesprochen sein.

Trotz dieser starken Zunahme ist die Gruppe erst relativ spät (1899) von Sharp in Abteilungen zerstreut worden und zwar wohl nur unter hauptsächlicher Berücksichtigung der zentralamerikanischen Arten. Hier mögen zunächst einmal Angaben über die geographische Verbreitung folgen.

[1] The beetles of this important family, the Cucujidæ, commonly live under bark. Some of the species that live in stored food products are of great economic concern. The family is extensively represented in the Philippines where little is known of the native forms.—Editors.

[2] Archiv f. Naturgesch. 87 Heft 6, 25–35, im alten Umfange.

I. AFRIKA (KONTINENT)

1. *Læmophlœus ater* Ol., Nord-Afrika.
2. *Læmophlœus bolivari* Gr., Spanisch Guinea.
3. *Læmophlœus brunneus* Gr., Sierra Leone.
4. *Læmophlœus biskrensis* Gr., Nord-Afrika.
5. *Læmophlœus clarus* Gr., Cap der guten Hoffnung.
6. *Læmophlœus curtipennis* Gr., Spanisch Guinea.
7. *Læmophlœus elongatulus* Luc., Algier.
8. *Læmophlœus escalerae* Gr., Spanisch Guinea.
9. *Læmophlœus faneti* Grouv., West-Afrika.
10. *Læmophlœus mirus* Gr., Spanisch Guinea.
11. *Læmophlœus misellus* Gr., Kamerun.
12. *Læmophlœus mobilis* Gr., Sansibar.
13. *Læmophlœus nigricollis* Luc., Algier.
14. *Læmophlœus patens* Gr., Sansibar.
15. *Læmophlœus peculiaris* Gr., Spanisch Guinea.
16. *Læmophlœus peringueyi* Gr., Cap der guten Hoffnung.
17. *Læmophlœus perrisi* Gr., Algier.
18. *Læmophlœus perspicuus* Gr., Cap der guten Hoffnung.
19. *Læmophlœus plagiatus* Gr., Spanisch Guinea.
20. *Læmophlœus rufipes* Luc., Algier.
21. *Læmophlœus suberis* Luc., Algier.
22. *Læmophlœus subniger* Gr., Spanisch Guinea.

II. AUSTRALIEN (KONTINENT)

1. *Læmophlœus bistriatus* Gr.
2. *Læmophlœus contaminatus* Gr.
3. *Læmophlœus felix* Kess.
4. *Læmophlœus insignis* Gr.
5. *Læmophlœus juvencus* Kess.
6. *Læmophlœus leachi* Gr.
7. *Læmophlœus lepidus* Gr.
8. *Læmophlœus parvulus* Gr.
9. *Læmophlœus tasmanicus* Gr.
10. *Læmophlœus tuberculatus* Gr.

III. AUSTRALIEN (INSULAR)

1. *Læmophlœus beccarii* Gr.
2. *Læmophlœus brevis* Fairm.
3. *Læmophlœus dorsalis* Gr.
4. *Læmophlœus falcidens* Gr.
5. *Læmophlœus fauveli* Gr.
6. *Læmophlœus gestroi* Gr.
7. *Læmophlœus humeralis* Gr.
8. *Læmophlœus ignotus* Kess.
9. *Læmophlœus insularis* Kess.
10. *Læmophlœus integer* Gr.
11. *Læmophlœus neglectus* Gr.
12. *Læmophlœus patens* Gr.
13. *Læmophlœus* subgranulatus Gr.
14. *Læmophlœus tricostatus* Montrouz.

IV. AZOREN UND CAPVERDISCHE INSELN

1. *Læmophlœus axillaris* Woll., Madera.
2. *Læmophlœus clavicollis* Woll., Madera.
3. *Læmophlœus donacioides* Woll., Madera.
4. *Læmophlœus granulatus* Woll., Madera.
5. *Læmophlœus politissimus* Woll., Cap Verde.
6. *Læmophlœus stenoides* Woll., Madera.

V. BOLIVIA

1. *Læmophlœus germaini* Gr.
2. *Læmophlœus nigrifrons* Gr.
3. *Rhinomalus fulvicollis* Gr.

VI. BORNEO

1. *Læmophlœus lepidus* Gr.
2. *Læmophlœus ovalis* Gr.

VII. BRASILIEN

1. *Læmophlœus aeneus* Gr.
2. *Læmophlœus castaneipennis* Gr.
3. *Læmophlœus curtus* Gr.
4. *Læmophlœus deletus* Gr.
5. *Læmophlœus grouvellei* Gr.
6. *Læmophlœus impressus* Gr.
7. *Læmophlœus lacerdae* Gr.
8. *Læmophlœus mathani* Gr.
9. *Læmophlœus megacephalus* Gr.
10. *Læmophlœus mixtus* Gr.
11. *Læmophlœus ovipennis* Rtt.
12. *Læmophlœus pallidipennis* Rtt.
13. *Læmophlœus pallentipennis* Grouv.
14. *Læmophlœus pilatei* Gr.
15. *Læmophlœus quinquearticulatus* Gr.
16. *Læmophlœus reitteri* Gr.
17. *Læmophlœus repandus* Rtt.
18. *Læmophlœus stramineus* Rtt.
19. *Læmophlœus straminipennis* Rtt.
20. *Læmophlœus uncicornis* Rtt.
21. *Rhinomalus elegans* Gr.
22. *Rhinomalus facetus* Gr.
23. *Rhinomalus ruficollis* Gr.
24. *Rhinomalus unifasciatus* Gr.
25. *Rhinophlœus productus* Gr.
26. *Rhinophlœus salpingoïdes* Gr.

VIII. CEYLON

1. *Læmophlœus atratulus* Gr.
2. *Læmophlœus coloratus* Gr.
3. *Læmophlœus divaricatus* Gr.
4. *Læmophlœus foveolatus* Rtt.
5. *Læmophlœus hypocrita* Gr.
6. *Læmophlœus insinuans* Gr.
7. *Læmophlœus orientalis* Gr.
8. *Læmophlœus subtestaceus* Gr.

IX. COLUMBIA

1. *Læmophlœus castaneipennis* Gr.
2. *Læmophlœus germaini* Gr.
3. *Læmophlœus iteratus* Shp.
4. *Læmophlœus lucanoïdes* Smith.
5. *Læmophlœus macrognathus* Rtt.
6. *Læmophlœus megacephalus* Gr.
7. *Læmophlœus pallentipennis* Gr.
8. *Læmophlœus recticollis* Rtt.
9. *Læmophlœus semiaeneus* Rtt.
10. *Læmophlœus semiflavus* Rtt.
11. *Læmophlœus seminiger* Rtt.
12. *Læmophlœus suturalis* Rtt.

X. WESTINDISCHEN INSELN, CUBA, ETC.

1. *Læmophlœus bicolor* Chevr.
2. *Læmophlœus chevrolati* Gr.
3. *Læmophlœus commixtus* Gr., Guadeloupe.
4. *Læmophlœus dufani* Gr., Guadeloupe.
5. *Læmophlœus exquisitus* Gr., Guadeloupe.
6. *Læmophlœus pallentipennis* Gr.
7. *Læmophlœus permixtus* Gr.
8. *Læmophlœus uncicornis* Rtt.

XI. EUROPA

1. *Læmophlœus abietis* Wankow., Nord-Europa, Mittel-Europa.
2. *Læmophlœus ater* Ol., Mittel-Europa, Süd-Europa.
3. *Læmophlœus* var. *capensis* Waltl, Mittel-Europa, Süd-Europa.
4. *Læmophlœus bimaculatus* Payk., Nord-Europa, Mittel-Europa.
5. *Læmophlœus brevicornis* Thoms., Nord-Europa.
6. *Læmophlœus castaneus* Er., Mittel-Europa, Süd-Europa.
7. *Læmophlœus clematidis* Er., Mittel-Europa, Süd-Europa.
8. *Læmophlœus corticinus* Er., Nord-Europa, Mittel-Europa.
9. *Læmophlœus duplicatus* Waltl, Süd-Europa.
10. *Læmophlœus emgei* Rtt., Süd-Europa.
11. *Læmophlœus fractipennis* Motsch., Süd-Europa.
12. *Læmophlœus hypobori* Perris, Mittel-Europa, Süd-Europa.
13. *Læmophlœus infuscatus* Motsch., Ost-Europa.
14. *Læmophlœus juniperi* Gr., Süd-Europa.
15. *Læmophlœus kraussi* Gglb., Mittel-Europa.
16. *Læmophlœus monilis* Fabr., Nord-Europa, Mittel-Europa.
17. *Læmophlœus muticus* Fabr., Nord-Europa, Mittel-Europa.
18. *Læmophlœus nigricollis* Luc., Mittel-Europa, Süd-Europa, Ost-Europa.
19. *Læmophlœus perrisi* Gr., Korsika.
20. *Læmophlœus puncticollis* Fleischer, Nord-Europa.
21. *Læmophlœus steppensis* Motsch., Ost-Europa.
22. *Læmophlœus weisei,* Nord-Europa.

XII. GUATEMALA

1. *Deinophloeus ducalis* Shp.
2. *Læmophlœus addendus* Shp.
3. *Læmophlœus alticola* Shp.
4. *Læmophlœus annectens* Shp.
5. *Læmophlœus boops* Shp.
6. *Læmophlœus celatus* Shp.
7. *Læmophlœus championi* Shp.
8. *Læmophlœus clavicornis* Shp.
9. *Læmophlœus convexus* Gr.
10. *Læmophlœus corporalis* Shp.
11. *Læmophlœus distans* Shp.
12. *Læmophlœus distinguendus* Shp.
13. *Læmophlœus endomychus* Shp.
14. *Læmophlœus flavescens* Shp.
15. *Læmophlœus frequens* Shp.
16. *Læmophlœus germaini* Gr.
17. *Læmophlœus guatemalenus* Shp.
18. *Læmophlœus hoplites* Shp.
19. *Læmophlœus ignobilis* Shp.
20. *Læmophlœus incisus* Shp.
21. *Læmophlœus insolitus* Shp.
22. *Læmophlœus inusitus* Shp.
23. *Læmophlœus iteratus* Shp.
24. *Læmophlœus optatus* Shp.
25. *Læmophlœus pallentipennis* Gr.
26. *Læmophlœus puncticollis* Shp.[3]
27. *Læmophlœus recticollis* Rtt.
28. *Læmophlœus suturalis* Rtt.
29. *Parandrita capito* Gr.
30. *Parandrita deceptor* Shp.
31. *Parandrita stipes* Shp.

[3] Da der Name *puncticollis* von Fleischer bereits (1829) für eine europäische *Læmophlœus*-Art vergeben wurde, wird an Stelle des Sharp'schen Namens ein anderer zu treten haben.

XII. GUATEMALA—Continued

32. *Rhabdophlœus concolor* Shp.
33. *Rhabdophlœus costatus* Shp.
34. *Rhabdophlœus dispar* Shp.
35. *Rhinomalus signatus* Shp.
36. *Rhinophlœus gracilis* Shp.
37. *Rhinophlœus nasutus* Shp.
38. *Rhinophlœus productus* Gr.
39. *Rhinophlœus salpingoides* Gr.
40. *Silvanophlœus bembidium* Shp.
41. *Silvanophlœus cognatus* Shp.
42. *Silvanophlœus fraudator* Shp.
43. *Silvanophlœus gundlachi* Shp.
44. *Silvanophlœus infimus* Shp.

XIII. HONDURAS

1. *Læmophlœus iteratus* Shp.
2. *Læmophlœus pallentipennis* Gr.
3. *Læmophlœus recticollis* Rtt.
4. *Silvanophlœus gundlachi* Gr.

XIV. HINTER-INDIEN

1. *Læmophlœus carinicollis* Gr.
2. *Læmophlœus invertus* Gr.
3. *Læmophlœus lepidus* Gr.
4. *Læmophlœus mandibularis* Gr.
5. *Læmophlœus rugifrons* Gr.
6. *Læmophlœus spinosus* Gr.
7. *Læmophlœus subtestaceus* Gr.

XV. VORDER-INDIEN

1. *Læmophlœus belli* Gr.
2. *Læmophlœus calognathus* Gr.
3. *Læmophlœus ditomoïdes* Gr.
4. *Læmophlœus dorcoïdes* Rtt.
5. *Læmophlœus falcidens* Gr.
6. *Læmophlœus harmandi* Gr.
7. *Læmophlœus incertus* Gr.
8. *Læmophlœus indicus* Gr.
9. *Læmophlœus interceptus* Gr.
10. *Læmophlœus faneti* Gr.
11. *Læmophlœus neglectus* Gr.
12. *Læmophlœus picipennis* Gr.
13. *Læmophlœus sanguinolentus* Hope.

XVI. JAPAN

1. *Læmophlœus convexiusculus* Gr.
2. *Læmophlœus dorcoïdes* Rtt.
3. *Læmophlœus laevior* Rtt.
4. *Læmophlœus nigrofasciatus* Rtt.

XVII. JAVA

1. *Læmophlœus incertus* Gr.

XVIII. KOSMOPOLITEN

1. *Læmophlœus alternans* Erichs.
2. *Læmophlœus ferrugineus* Steph.
3. *Læmophlœus minutus* Ol.
4. *Læmophlœus turcicus* Gr.
5. *Silvanophlœus testaceus* Fabr.

XIX. MADAGASKAR UND REUNION

1. *Læmophlœus allnaudi* Gr., Madagaskar.
2. *Læmophlœus atratulus* Gr., Madagaskar und Reunion.
3. *Læmophlœus brevipennis* Gr., Madagaskar.
4. Læmophlœus *coquereli* Gr., Madagaskar und Reunion.
5. *Læmophlœus cornutus* Gr., Madagaskar.
6. *Læmophlœus fairmairei* Gr., Madagaskar.
7. *Læmophlœus faneti* Gr., Madagaskar.
8. *Læmophlœus mirificus* Gr., Reunion.

XIX. MADAGASKAR UND REUNION—Continued

9. *Læmophlœus mirus* Gr., Madagaskar.
10. *Læmophlœus perrieri* Gr., Madagaskar.
11. *Læmophlœus planulatus* Gr., Reunion.
12. *Læmophlœus raffrayi* Gr., Madagaskar.
13. *Læmophlœus sulcifrons* Gr., Reunion.
14. *Læmophlœus tenebrosus* Gr., Reunion.

XX. MEXICO

1. *Deinophlœus ducalis* Shp.
2. *Læmophlœus amulae* Shp.
3. *Læmophlœus hoplites* Shp.
4. *Læmophlœus ignobilis* Shp.
5. *Læmophlœus iteratus* Shp.
6. *Læmophlœus minusculus* Gr.
7. *Læmophlœus pallentipennis* Gr.
8. *Læmophlœus pauper* Shp.
9. *Læmophlœus recticollis* Rtt.
10. *Læmophlœus suturalis* Rtt.
11. *Læmophlœus suturalis* var. *circumdatus* Shp.
12. *Læmophlœus teapensis* Grouv.
13. *Læmophlœus uncicornis* Rtt.
14. *Parandrita capito* Gr.
15. *Parandrita stipes* Shp.
16. *Rhabdophlœus concolor* Shp.
17. *Rhabdophlœus costatus* Shp.
18. *Rhinomalus anthracinus* Shp.
19. *Rhinomalus chiriquensis* Shp.
20. *Rhinomalus vicinus* Gr.
21. *Rhinophlœus nasutus* Shp.
22. *Rhinophlœus productus* Gr.
23. *Rhinophlœus salpingoides* Gr.
24. *Silvanophlœus gundlachi* Gr.

XXI. NICARAGUA

1. *Læmophlœus ignobilis* Shp.
2. *Læmophlœus pallentipennis* Gr

XXII. PANAMA

1. *Læmophlœus anticus* Shp.
2. *Læmophlœus breviceps* Shp.
3. *Læmophlœus carabinus* Shp.
4. *Læmophlœus convexus* Gr.
5. *Læmophlœus curtus* Gr.
6. *Læmophlœus distinguendus* Shp.
7. *Læmophlœus dives* Shp.
8. *Læmophlœus frequens* Shp.
9. *Læmophlœus immersus* Shp.
10. *Læmophlœus incisus* Shp.
11. *Læmophlæus minutus* Shp.[4]
12. *Læmophlœus pallentipennis* Gr.
13. *Læmophlœus striatus* Shp.
14. *Læmophlœus suturalis* Rtt.
15. *Deinophlœus sinuatus* Shp.
16. *Rhabdophlœus chiriquensis* Shp.
17. *Rhinomalus chiriquensis* Shp.
18. *Silvanophlœus atomarius* Shp.
19. *Silvanophlœus gundlachi* Gr.

XXIII. PHILIPPINEN

1. *Læmophlœus philippinicus* Kess.

XXIV. SUMATRA

1. *Læmophlœus atratulus* Gr.
2. *Læmophlœus decoratus* Gr.
3. *Læmophlœus incertus* Gr.
4. *Læmophlœus mandibularis* Gr.
5. *Læmophlœus proximus* Gr.
6. *Læmophlœus subtestaceus* Gr.

[4] Der Name *minutus* ist bereits (1791) von Olivier für eine kosmopolitische *Læmophlœus*-Art vergeben. Cf. Bemerkung sub. XII, 26.

XXV. VENEZUELA

1. *Læmophlœus albofasciatus* Gr.
2. *Læmophlœus castaneipennis* Gr.
3. *Læmophlœus pallentipennis* Gr.
4. *Læmophlœus obliquefasciatus* Gr.

XXVI. VEREINIGTE STAATEN VON NORD-AMERIKA

1. *Dysmerus basalis* Casey (vielleicht Synonym zu *Læmophlœus uncicornis* Rtt.).
2. *Læmophlœus adustus* Lec.
3. *Læmophlœus angustulus* Lec.
4. *Læmophlœus biguttatus* Say.
5. *Læmophlœus cephalotes* Lec.
6. *Læmophlœus chamaeropsis* Schwarz, Süd-Amerika.
7. *Læmophlœus convexulus* Lec.
8. *Læmophlœus denticornis* Casey.
9. *Læmophlœus extricatus* Casey.
10. *Læmophlœus fasciatus* Melsch.
11. *Læmophlœus floridanus* Casey.
12. *Læmophlæus horni* Casey.
13. *Læmophlœus lecontei* Gr.
14. *Læmophlœus longicornis* Mannh.
15. *Læmophlœus modestus* Say.
16. *Læmophlœus puberulus* Lec.
17. *Læmophlœus pubescens* Casey.
18. *Læmophlœus punctatus* Lec.
19. *Læmophlœus quadratus* Casey.
20. *Læmophlœus rotundicollis* Casey.
21. *Læmophlœus schwarzi* Casey.
22. *Læmophlœus terminatus* Casey.
23. *Læmophlœus truncatus* Casey.
24. *Silvanophlœus niteus* Lec.

Die Aufstellung zeigt, dass einzelne Regionen, besonders Ost-Asien, in Bezug auf *Læmophlœus*-Arten noch sehr wenig

FIG. 1. *Læmophlœus (Brontophlœus) uncicornis* Rtt.; *a*, Fühler des Männchens; *b*, Fühler des Weibchens.

durchforscht sind. Dankbar wäre ich, wenn Museen und Privat-Sammler, welche diese Zeilen lesen, meine Studien durch Mitteilung von Fundorten unterstützen wollten. Auch benötige ich für meine anatomischen Arbeiten sehr viel Material, für das ich im Tausch gegebenen Falle brasilianische Coleoptera oder Lepidoptera abgebe.

190404——7

ILLUSTRATION

TEXTFIG. 1. *Læmophlœus* (*Brontophlœus*) *uncicornis* Rtt.; *a*, Fühler des Männchens; *b*, Fühler des Weibchens.

NOUVEAUX CERCOPIDES DES PHILIPPINES

Par V. LALLEMAND

Uecle, Bruxelles

Genus **PHYMATOSTETHA** Stål

Phymatostetha rubens sp. nov.

Tête, pronotum, écusson sont rouge-brique, élytres rouge-brique, devenant rouge-jaunâtre à la partie réticulée; sur le vertex, à sa base, entre les yeux, une ligne transversale, sur le pronotum les 2 fossettes situées en arrière des yeux, une fine bande longitudinale et 4 taches sur les élytres sont noirâtres. Le front près des yeux est légèrement brunâtre. Voici la disposition des bandes et taches, des élytres: la bande longitudinale s'étend depuis la base sur le tiers antérieur le long du radius; près du bord externe, de suite aprés le milieu, se trouve une première tache s'étendant jusqu'au médian et ayant deux pointes vers l'arrière, entre le médian et le cubitus se trouve la deuxième qui est arrondie; en avant de la partie réticulée se trouvent les taches 3 et 4 une au bord externe et l'autre en arrière de la tache no 2. Les ailes sont enfumées, a base rosée. Rostre, thorax noirs (sauf l'extrémité des protubérances et les hanches rouges) pattes rouges, sauf le milieu des cuisses et les épines des tarses postérieurs qui sont brunes. Le premièr segment de l'abdomen est noir bordé de rouge, les autres sont rouges portant de chaque côté une tache transversale noire, la base des organes génitaux et la tarrière sont noires; la partie supérieure de l'abdomen est rouge. Pronotum fortement et grossièrement ponctué en séries transversales, la carêne longitudinale est peu marquée, son bord postérieur est concave, arrondi. Le mésothorax présente deux protubérances en avant des hanches médianes, dont la face antérieure est en pente, tandis que la face postérieure tombe droit. Longueur totale, 17 mm.; longueur des élytres, 13 mm.

LUZON, Laguna, Mount Maquiling (*Baker*).

Phymatostetha dapitana sp. nov.

Espèce voisine de *P. mactans* White et surtout de *flavopicta* Distant. La tête est jaune sauf une bande transversale entre

les yeux à la base du vertex et une tache de chaque côté du front au devant des yeux, qui sont noirs. Le pronotum est jaune portant 2 larges bandes longitudinales noires n'atteignant pas le bord antérieur; écusson noir. Elytres noirs, ils ont 3 bandes et 3 taches jaunes, une large bande droite sur le clavus longeant le bord interne jusque vers la naissance de la pointe de l'écusson, puis s'en écartant elle est plus large à son extrémité qu'a la base; une deuxième bande le long du bord externe s'étendant aussi loin que la première; un peu en arrière de ces 2 premières se trouve une bande transversale légèrement ondulée, quant aux taches, les 2 premières sont situées en avant de la partie réticulée, une au bord externe et l'autre au bord interne vers la pointe du clavus, la troisième se trouve en arrière de celles-ci, au milieu; les ailes sont noirâtres; l'abdomen est jaune-foncé à sa face supérieure, à sa face inférieure le premier segment est noirâtre bordé de jaune-foncé et les autres sont jaune-foncé portant 4 taches noires, 2 petites triangulaires á la base et au milieu, et une grosse tache de chaque côté; la base des organes génitaux et la tarriére sont noirâtres. Longueur totale, 19 mm.; longueur des élytres, 15 mm.

MINDANAO, Dapitan (*Baker*).

Phymatostetha cincta sp. nov.

Espèce voisine de *Phymatostetha circumducta* Walker, *ståli* Butler, et *hilaris* Walker.

La tête est noire sauf les parties latérales du vertex et une tache triangulaire frontale qui sont jaunes; pronotum noir sauf une bande jaune le long des bords antérieurs et latéro-antérieurs, la bande antérieure est de dimensions inégales, large au milieu, elle se rétrécit sur les côtés, en effet les fossettes latérales du pronotum (qui se trouvent en arrière des yeux) occupent cette bande et sont de la même couleur que le disque; l'écusson est noir, une bande jaune occupe le tiers basal. Les élytres brun-noir sont recouvertes d'une villosité dense et jaune-gris, sur celles-ci se voient 2 bandes transversales, deux bandes longitudinales et une fine bordure jaunâtre. La première bande transversale se trouve en avant du milieu et le dieuxème au devant de la partie réticulée; la bande longitudinale sur le clavus longe le bord interne; elle s'étend jusqu'au niveau du milieu de l'écusson, la dieuxème longeant le bord externe se rétrécit brusquement un peu en avant de la première bande transversale et sous la forme d'un mince filet borde l'élytre jusqu'a la pointe du clavus. Les ailes sont enfumées à base rougeâtre. Thorax ocre-jaune

sauf les protubérances qui sont noires. Pattes jaune-brunâtre, sur les cuisses se trouvent 2 bandes longitudinales, noires et la moitié apicale des tibias est foncée, l'abdomen est bleu-violet à sa partie supérieure et jaunâtre à sa partie inférieure, sauf le premier segment qui est noirâtre mais bordé de jaune et une tache noire de chaque côté sur chaque segment.

Un exemplaire que je possede de Balabac a les dessins rouges au lieu de jaunes comme pour ceux de Palawan.

La surface du pronotum est rugueuse densement et grossièrement striée en lignes transversales, elle porte une carêne longitudinale commençant à une certaine distance du bord antérieur; l'écusson porte une fossette centrale, sa surface est transversalement striée; les ocelles sont très proches l'un de l'autre, la distance qui les sépare des yeux est égale à trois fois leur écartement. La face est globuleuse transversalement striée; les protubérances du mésothorax sont situées au devant des hanches médianes elles sont peu élevées, transversales. Longueur totale, 14 mm.; longueur des élytres, 10.5 mm.

Cette espèce se distingue de *P. ståli* Butler et *hilaris* Walker par la coloration du vertex, par la forme de la bande antérieure du pronotum et par la bande de l'écusson.

PALAWAN. BALABAC.

Type.—La collection du musée de Paris (Ile Palawan) et ma collection (Balabac).

Phymatostetha iligana sp. nov.

L'insecte est tout noir sauf les taches ou bandes dont la description suit et qui sont jaunes; le bord antérieur du vertex se prolongeant en une tache triangulaire jaune-brun sur le front, les bords antérieurs et latéro-antérieurs du pronotum et une ligne longitudinale médiane; sur les élytres: une bande transversale au devant du milieu, deux taches au devant de la partie apicale, une au bord externe et une autre à l'extrémité du clavus, enfin une troisième au milieu de la partie apicale, une bande longitudinale s'étendant sur le subcosta mais n'atteignant pas la bande transversale, sur le clavus une bande droite partant de la base, longeant le bord interne jusqu'à l'extrémité du pronotum, puis s'en écartant, le bord interne lui-même jusqu'á la première bande transverse est rougeâtre; les ailes ont leur base rougeâtre. A l'extrémité du front, près du clypeus existe de chaque côté une tache jaune; les hanches et la base des cuisses, de même que l'extréme bord de chaque segment, abdominaux sont également jaunes; les protubérances du mésothorax sont bien développées,

leur extrémité est plus claire. Longueur totale, 16 mm.; longueur des élytres, 12 mm.

Cette espèce, par le dessin des élytres est voisine de *P. mactans* White, *flavopicta* Distant, *dapitana* sp. nov.

MINDANAO, Iligan (*Baker*).

Genus **LEPTATASPIS** Schmidt

Leptataspis butuanensis sp. nov.

L'insecte est noir, sauf une bande transversale rouge qui occupe à peu près le quart basal des élytres et dont le bord postérieur n'est pas droit, la bande s'étend un peu plus en arrière a la partie externe de l'élytre, en dehors du radius; la base des ailes est également rougeâtre. Les élytres sont longues à peu près 3 fois leur largeur (16 mm x 6 mm) le médian et le cubitus sont réunis sur le tiers basal.

La surface du pronotum est lisse, brillante, finement ponctuée, portant une carêne dans sa partie antérieure, celle-ci se continue par un sillon à la partie postérieure. Les ocelles sont à égale distance l'un de l'autre.

Le rostre s'étend jusqu'entre les hanches médianes; les protubérances du mésothorax sont transverses et non en cône, légérement dirigées en avant, le bord postérieur du mésothorax est foliacé. Longueur totale, 20 mm.; longueur des élytres, 16 mm.; largueur des élytres, 6 mm.

MINDANAO, Agusan, Butuan (*Baker*).

Leptataspis bukidnona sp. nov.

Ecusson, pronotum tête et thorax rouge-brun, brillants; moitié basale des élytres ocre-jaune, moitié apicale noire. Sur la partie antérieure existent 8 taches noires, une près de la base sur le médian et une seconde sur la première nervure du clavus non loin de la base, ensuite une bande transversale composée de 4 taches, une prés du bord externe, une deuxiéme sur le tronc commun du médian et du cubitus et 2 sur le clavus, séparées par la première nervure; enfin une seconde bande composée de 2 taches, la première près du bord externe, au devant de la bifurcation du radius, la dieuxième entre le médian et le cubitus bifurqués; l'abdomen est noir. Toute la surface de l'insecte est recouverte d'une villosité noire. Le médian, le cubitus sont réunis sur le tiers basal des élytres.

La surface du pronotum est lisse et brillante finement ponctuée, sur la moitié antérieure du pronotum existe une carêne médiane qui se continue par un fin sillon, les protubérances du

mésothorax sont bien développées, transversales, son bord postérieur est foliacé. Longueur totale, 19 mm.; longueur des élytres, 14 mm.; largeur des élytres, 5.5 mm.

MINDANAO, Bukidnon, Tangcolan (*Baker*).

Genus **OPISTARSOSTETHUS** Schmidt

Opistarsostethus calypso sp. nov.

Tête, pronotum, pattes antérieures, l'extrême base et le tiers antérieur du bord externe des élytres sont rouge brique. Tibias et tarses médians et postérieurs brun-rougeâtre, tout le restant de l'insecte est noir sauf 7 petites taches rouge-clair sur les élytres, les 4 premières sont placées en une série transversale au devant du milieu, la première très petite est située près du bord externe, la dieuxième de même dimension et très voisine de la première, près du radius, la troisième entre la médian et le cubitus, la quatriême sur le clavus. Les 3 autres se trouvent au devant de la partie réticulée, une au bord externe, la dieuxième entre le radius II et le médian, la troisième transversale près de la pointe du clavus sur le cubitus.

La surface du pronotum est quelque peu rugueuse, transversalement et fortement ponctuée, elle montre une carêne médiane très nette, son bord postérieur est anguleux et concave, les angles latéraux sont arrondis, sur les élytres le médian et le cubitus sont réunis par un rameau transversal. Le rostre s'étend jusqu'au devant des hanches médianes. Les protubérances du mésothorax sont transversales, son bord postérieur est foliacé. Longueur totale, 21 mm.; longueur des élytres, 17 mm.; largeur des élytres, 6.5 mm.

POLILLO (*Edward H. Taylor*).

Genus **RADIOSCARTA** novum

Front dans son ensemble assez globuleux, partagé en 3 parties nettes, une médiane et 2 latérales séparées par des carènes èmoussées, la partie médiane est très légérement et transversalement bombée a sillons transversaux peu marqués, sans carêne ni sillon longitudinal médian. Vu de côté et dans le sens de la longueur, le bord antérieur est légèrement incurvé, le postérieur est droit et l'angle formé est un peu plus grand que le droit. Le rostre assez long s'étend jusque près des hanches médianes. Les élytres ont le bord externe convexe, leur plus grande largeur est située vers la fin du tiers antérieur, le médian et le cubitus ne sont pas soudés, ils sont réunis par un rameau oblique. Sur les ailes,

le rameau transverse réunissant le dieuxième au troisième secteur est situé bien en avant de la bifurcation du troisième secteur. La partie antérieure du pronotum et le vertex sont déclives, la distance séparant les ocelles des yeux est le double de leur écartement, le vertex est plus large que long. Le pronotum a ses angles latéraux arrondis, il porte une fine carêne longitudinale. L'écusson est creusé en une fossette médiane. Le mésothorax est sans protubérance, en bourrelet transversal. Les tibias postérieurs ont 2 épines, une petite à la base, et une forte au milieu.

Type du genre, *Radioscarta surigaona* sp. nov.

Radioscarta surigaona sp. nov.

L'insecte est tout brun, sauf le mésothorax qui est ocre-jaune. Le milieu du front, le bord latéral du vertex et une tache au devant des ocelles ainsi que 2 petites taches près du bord postérieur sont jaunes. Sur le pronotum chez la femelle existe une fine ligne transversalé ondulée jaune, tandis que chez le mâle existe une large bande transversale jaune, qui occupe à peu près toute la moitié antérieure, mais qui ne s'étend pas jusqu'au bord antérieur: la pointe de l'écusson est jaunâtre; sur les élytres se voit au devant du milieu une ligne transversale plus ou moins droite composée de 7 taches blanches, 5 sur le corium et 2 sur le clavus, au devant de la partie réticulée existent 2 taches transversales, une au bord externe et l'autre à l'extrémité du clavus, un peu en arrière de celles-ci et sur le milieu se trouve une troisième tache arrondie. Les ailes sont enfumées, les nervures sont noires; la tête est arrondie à son bord antérieur; pronotum densement ponctué, ses bords antérieurs sont droits, son bord postérieur est concave et arrondi, l'angle latéral est arrondi, les tibias postérieurs ont 2 épines. Mâle, longueur totale, 10.5 mm.; longueur des élytres, 8.5 mm.; largeur des élytres, 3 mm. Femelle, longueur totale, 8 mm.; longueur des élytres, 6.5 mm.; largeur des élytres, 2.5 mm.

MINDANAO, Surigao, Surigao (*Baker*).

Genus **EUGLOBICEPS** novum

Front globuleux, arrondi lisse à sillons peu marqués à la partie médiane, la forme de la tête rappelle le genre *Abidama* Distant, la longueur de la partie visible d'en haut est plus grande que la largeur de la partie du vertex comprise entre les yeux; les ocelles sont petits, plus près l'un de l'autre que des yeux et séparés par une carêne; le vertex et la partie frontale du vertex sont plats, à bord antérieur arrondi: pronotum un peu rugueux, à

fossettes antérieures, bord latéro-antérieur droit, bord postérieur un peu concave arrondi, il n'a pas de carêne. Ecusson à fossette médiane. Sur le tiers basal des élytres le médian et le cubitus sont réunis, les nervures sont relativement peu marquées, le réseau apical est bien visible mais peu saillant, la longueur des élytres est a peu près ègale á 3 fois leur largeur, l'endroit le plus large est au devant de la partie apicale réticulée, le mésothorax est bombé transverse, sans protubérances. Le rostre à 2 articles d'égale longueur et s'étend jusqu'entre les hanches médianes. Les cuisses antérieures et médianes montrent une fossette longitudinale occupant à peu près toute la longeur et rappelant celle du genre *Notoscarta* Breddin. Les tarses postérieures n'ont qu'une épine.

Type du genre, *Euglobiceps elongata* sp. nov.

Euglobiceps elongata sp. nov.

Toute la surface de l'insecte, spécialement les élytres et le pronotum, est recouvert d'une villosité dense jaune-gris. Tête d'un brun-acajou, pronotum, écusson (sauf l'extrémité, rouge) élytres brunes, thorax rose, abdomen rose sauf les 2 derniers segments et les organes génitaux (sauf la base de la tarrière, rose) qui sont brunâtres; pattes roses sauf les tibias et les tarses antérieurs et médians, les épines et les tarses postérieurs. Longueur totale, 8 mm.; longueur des élytres, 6 mm.

MINDANAO, Dapitan (*Baker*).

Genus **EUBAKERIELLA** novum

Pronotum rugueux, grossièrement ponctué, à carêne médiane, à bord postérieur fortement convexe arrondi.

Ecusson allongé, effilé: élytres à nervures très fortement saillantes, médian et cubitus réunis sur un court trajet, sur toute la surface de l'élytre existent des rameaux transverses.

Les protubérances du mésothorax sont bien développées, légèrement transverses, son bord postérieur est foliacé. Les ocelles sont petits, à distance égale l'un de l'autre et des yeux, la partie frontale du vertex est nettement séparée du vertex par des sillons et elle se continue sans interruption avec le front qui est globuleux et dont la surface montre des sillons transversaux. Ce genre est voisin de *Phlebarcys* Schmidt par les nervures saillantes, qui occupent à peu près toute la surface de l'élytre (corium et clavus) ; il s'en distingue également par la forme du front et le bord postérieur du pronotum qui est convexe.

Type du genre, *Eubakeriella spectabilis* sp. nov.

Eubakeriella spectabilis sp. nov.

Elytres brunes à reflets métalliques verdâtres sur les 2 tiers antérieurs. Pronotum brun à légers reflets verts, bord antérieur noir-vert et les autres bords sont ocre-jaune; tête noire à reflets verts, clypeus, rostre, pattes, tarrière du mâle jaunes, thorax noir (sauf une bande latérale jaune du mésothorax) ; l'abdomen est noir, à reflets bleus métalliques à la face supérieure et verts à la face inférieure. Toute la surface de l'insecte est recouverte d'une villosité grise spécialement à la face inférieure. Longueur totale, 18 mm.; longueur des élytres , 8 mm.; largueur des élytres, 3 mm.

SUMATRA (*Corporaal*).

EFFECTS OF EXTRACTS OF ASCARIS VITOLORUM ON EXPERIMENTAL ANIMALS

By BENJAMIN SCHWARTZ

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INTRODUCTION

During the past few months a number of calves (Indian buffalo and native carabao) of the herd of the College of Agriculture died as a result of heavy infestation with *Ascaris vitolorum*, a species of rather common occurrence in bovine animals in the Philippine Islands. The animals in question exhibited severe symptoms, which became more intense following the administration of turpentine as an anthelminthic. As a result of anthelminthic medication the parasites were killed; but, despite the administration of rather heavy doses of castor oil, they were not eliminated from the intestine, as was shown by post-mortem examination.

The symptoms exhibited by the sick calves were those of extreme weakness combined with a rather pronounced toxæmia. Shortly before death the animals exhibited severe nervous reactions, such as vertigo and epilepsy, these symptoms being followed by complete prostration and death.

Post-mortem examination revealed numerous worms, many of which were dead, in the duodenum, a few worms in the stomach, and partially digested worms as well as fragments of worms in different portions of the intestines. Whether the death and resultant disintegration of the worms were responsible for the increase in the severity of the symptoms following the administration of turpentine could not be determined, because the sick animals were treated before I had an opportunity to keep one or more untreated animals as controls. Since the behavior of the sick calves before the administration of anthelminthics was indicative of toxæmia, it occurred to me that toxic substances, either true secretory products of the parasites or disintegration products following the death of the worms, might be responsible for the severe clinical manifestation of that parasitic condition.

The experiments herein discussed were undertaken with a view of obtaining information on that point. A more-detailed

series of experiments than those recorded in this paper was planned, but as no specimens of *Ascaris vitolorum* have been found recently, either in Los Baños or in abattoirs in Manila, I desire to record the results that have thus far been obtained.

TECHNIC

Extracts that were used in the experiments described were prepared from worms that were recovered during post-mortem examination of calves that succumbed to ascariasis. Only living specimens were selected for the purpose of preparing the extracts, and the specimens were thoroughly and repeatedly washed in physiological salt solution in order to free their surface from adhering intestinal matter. The worms were then dried with filter paper, placed in a glass dish, and cut into pieces about 2.5 centimeters long. The cut-up worms were placed in a desiccator containing calcium chloride, and after several days' drying the parasite material was sufficiently crisp to allow pulverization.

Extracts were prepared in physiological salt solution (0.85 per cent solution of sodium chloride) by suspending a certain quantity of triturated worm material in a certain quantity of salt solution, as noted in connection with each series of experiments, and allowing the mixture to remain in a cool, dark place for from two to three hours. The mixtures were then filtered, or the fluid was removed by means of a syringe without filtration.

Unless otherwise stated, animals were injected intraperitoneally, and the usual aseptic precautions were adhered to in the course of these experiments. All animals used in the experiments were full grown.

RECORDS OF EXPERIMENTS

SERIES I

The following extract was used in this series of experiments: One gram of finely powdered worm material was suspended in 10 cubic centimeters of physiological salt solution.

Experiment 1.—One and five-tenths cubic centimeters of the filtered extract was injected into guinea pig 1. About fifteen minutes after the injection the animal gave evidence of distress. The following symptoms were most pronounced: Severe scratching, marked trembling and excitation, and a rough coat. These symptoms gradually increased in severity and were followed by weakness in the legs, a tendency to fall down, and finally by paralysis. The animal was kept under observation for several

hours, during which period the symptoms did not subside. The following day the animal was found dead.

Experiment 2.—Guinea pig 2 was injected with the same quantity of extract as was used in experiment 1. The appearance and persistence of symptoms and the results were the same as in experiment 1.

SERIES II

The following extract was used in the experiments of this series: One gram of powder was suspended in 15 cubic centimeters of physiological salt solution.

Experiment 3.—Guinea pig 3 was injected with 1 cubic centimeter of extract. The symptoms were practically the same as those noted in experiment 1. There was a period during which the animal showed evidence of distress by running excitedly up and down the table and emitting shrill sounds from time to time. This was followed by a state of dullness and stupor, and complete prostration. This animal gradually recovered from the injection. It was kept under observation for several weeks, but showed no further symptoms.

Experiment 4.—Guinea pig 4 was injected with a quantity of extract equal to that used in experiment 3, but the extract was heated to boiling point and then allowed to cool before it was injected. The results were similar to those noted in experiment 3.

Experiment 5.—Guinea pig 5 was injected with 2 cubic centimeters of extract. It exhibited the same symptoms as guinea pigs 3 and 4, but its reactions were more pronounced. This animal was found dead the next morning.

Experiment 6.—Guinea pig 6 was given 5 cubic centimeters of extract by mouth. The animal became ill immediately after the administration of the extract, ran about excitedly along the table, squealed as if in pain, scratched its face violently, rubbed its mouth with its forelegs, and exhibited other nervous symptoms. The animal eventually recovered.

SERIES III

The powdered-worm material that was used in this and in the following series of experiments was obtained from the same lot of dried worms as was that used in Series I and II. Several months elapsed between the experiments in the first two series and those in subsequent series, and during the intervals the dried-worm material was kept in a tightly corked bottle in a dark place.

The extract used in this series of experiments was made up as follows: One-half gram of powdered-worm material was extracted in 10 cubic centimeters of physiological salt solution.

Experiment 7.—Guinea pig 7 was injected with 2 cubic centimeters of the extract. About five minutes after the injection the animal began to exhibit signs of uneasiness. Its fur became rough, its movements were spasmodic, and it ran about on the table very excitedly, emitting guttural sounds. Ten minutes later it showed weakness in the legs, and shifted its weight from side to side. Its eyes were only half open, and it fell down from time to time. About thirty minutes after the injection the guinea pig was completely prostrated. It remained under close observation for seven hours and throughout this period was very ill. Its respiration was rapid and shallow, and it was feverish and extremely sensitive to touch. Frequently it squealed as if in pain. The following day the guinea pig was quiet but rather weak. It refused food and drink. Gradually, however, the animal recovered fully from the effects of the injection.

Experiment 8.—Guinea pig 8 was injected with 3 cubic centimeters of the extract. The behavior of this animal was similar to that of guinea pig 7, but the symptoms appeared more rapidly and were more marked. This animal was very ill the day after the injection, but it finally recovered.

SERIES IV

The extract used in this series of experiments, which were performed about three weeks later than the experiments in Series III, was similar to that used in experiments 7 and 8. White rats were substituted for guinea pigs in experiments 9 and 10.

Experiment 9.—Rat 1 was injected with 1.4 cubic centimeters of the extract. Ten minutes after injection the animal became greatly excited, jumped up and down in the glass jar in which it was kept under observation, and scratched itself rather violently. About ten minutes later the rat was dull and listless, its fur was rough, its back was arched, its head drooping, and respiration labored, and its body jerked involuntarily from time to time. Forty-five minutes after injection the rat lay on its abdomen. This animal was sick for an entire day, during which it was kept under close observation. It remained listless and weak. The following day the animal was weak and did not eat. It recovered from the effects of the injection in two days.

Experiment 10.—Rat 2 was injected with 1 cubic centimeter of the extract. Its reactions were the same as those described for rat 1, but the symptoms appeared more slowly.

SERIES V

Three frogs and one turtle were used in this series of experiments and extract similar to that used in Series IV was injected in quantities of 1 cubic centimeter to each animal. No definite reactions were provoked, however, the animals appearing quite unaffected by the injections.

SUMMARY OF EXPERIMENTS

Physiological salt solution extracts of *Ascaris vitolorum* were quite toxic to guinea pigs and rats. The injection of these extracts intraperitoneally resulted in the appearance of a train of morbid symptoms characterized by a stage of heightened excitability, during which the animal gave evidence of acute distress, followed by a stage of dullness, stupor, and complete prostration, with fatal termination in several cases (experiments 1, 2, and 5). Boiling the extract did not destroy its toxicity (experiment 4), and the administration of the extract by mouth produced painful reactions (experiment 6). Cold-blooded vertebrates appeared quite refractory to injection with an extract of *Ascaris vitolorum* that was toxic to rats (Series V).

DISCUSSION OF RESULTS

The results of these experiments indicate that *Ascaris vitolorum* contains a powerful, toxic substance, or more than one such substance, capable of provoking marked reactions in guinea pigs and rats. Effects produced in these animals as a result of administering salt-solution extracts of *Ascaris vitolorum* were similar to the symptoms that were shown by calves heavily infested with this parasite. Sick calves suffering from gross infestation with *Ascaris* appeared dull, listless, with head drooping, emaciated, had no appetite, and during the acute stage of the disease which led to fatal results showed marked nervous symptoms, as has already been noted in this paper.

The pathogenicity of *Ascaris vitolorum* to calves has been noted by a number of investigators whose descriptions of the symptoms of the disease suggest a chronic intoxication of the host with resultant nervous symptoms as well as digestive disturbances.

The view that the toxic symptoms in helminthiasis are due to the absorption by the host of poisonous substances elaborated by parasites has been advanced by a number of investigators, who have based their conclusions on the toxic effects produced in laboratory animals following injection with extracts of parasitic worms. So far as I am aware, the experiments described in this paper afford more conclusive evidence than has yet been offered in favor of a toxæmia in a specific parasitic disease because not only were extracts of *Ascaris vitolorum* found to be toxic, but also the reactions provoked in susceptible laboratory animals were similar to the symptoms exhibited by normally infested calves.

SUMMARY

1. Physiological salt solution extracts of *Ascaris vitolorum* were found to be toxic to guinea pigs and rats, and nontoxic to frogs and to a turtle.

2. Toxic symptoms were provoked in susceptible animals by injecting them intraperitoneally with extracts of this worm and in one case by administering an extract by mouth. In one experiment an extract was still toxic after having been boiled.

3. The symptoms exhibited by susceptible animals injected with extracts of *Ascaris vitolorum* were heightened excitability, followed by a state of dullness and prostration that led to fatal termination in several instances.

4. There was a decided similarity in symptoms exhibited by calves normally parasitized by *Ascaris vitolorum* to those provoked in susceptible animals to which extracts of that parasite were administered.

5. The data presented in this paper afford more-conclusive evidence in favor of a chemical pathology in a specific helminthic disease than has been offered heretofore.

MICH.

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NATURAL IMMUNITY TO INFECTION AND RESISTANCE TO DISEASE, AS EXHIBITED BY THE ORIENTAL, WITH SPECIAL REFERENCE TO SIAMESE

By RALPH W. MENDELSON

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TWO TEXT FIGURES

In applying the principles of preventive medicine and hygiene to conditions as they are found in the Far East the health officer has not only to deal with a complex sanitary problem, which in its intricacy consists of bad water supplies, unheard-of methods of night-soil disposal, a complete inexistence of food-distribution supervision combined with an unlimited disregard for many other primary sanitary principles; but, also, he has first and last to overcome a prejudice, born of ignorance and superstition, which in its capacity to resist modern western theory and practice is simply Cyclopean. One who has never visited this part of the world, who has only second-hand knowledge of conditions as they actually present themselves, has not the remotest idea of what the actual state of affairs is. Parlor sanitarians are uncommonly successful in devising ways and means to be applied in combating the epidemic diseases, but practicing hygienists not infrequently discover the impracticability of many of the hard-and-fast rules as decreed, and in no place is this so pronounced as in the Orient.

My experience covers a period of five years. During that time I have, consciously and unconsciously, had my sanitary point of view considerably altered as regards this particular

part of the world. This is due to the natural immunity to infection and resistance to disease as exhibited by the Oriental. Nature produces rather remarkable results in the way of protection, and a full appreciation of that fact is of extreme importance to the sanitarian working in the Far East.

Let us first consider a few of the more-important food and water-borne diseases, of which the most important is cholera. This very serious disease must be considered as being and having been endemic in Siam for the last one hundred years. Although it is recorded as present in Java as far back as 1629, the first extensive epidemic outside India seems to have begun in 1817, and by 1820 had extended to China, having traveled via Burma, Singapore, and Manila. It does not seem remotely possible that this part of the country could have escaped the disease at that time, although in the literature Siam is not mentioned as suffering from cholera until 1906 as the result of the severe epidemic that started in India in 1900.

Topographically, climatically, and hygienically, Siam is an ideal spot for the propagation of cholera. A vast part of the country occupies an alluvial plain consisting of black, muddy, water-logged clay extensively polluted with decomposing matter. The sanitation is very bad, and practically all water supplies are unfit for domestic use with the exception of that from the modern plant in the City of Bangkok proper, completed in November, 1914, the influence of which is shown in the table of the vital statistics of the recent epidemic. The practice of using untreated fresh human fæces for fertilizing purposes is common throughout the country and the distribution of foodstuffs is quite uncontrolled. From the foregoing it is evident that more-ideal conditions could hardly exist for the spread of an acute epidemic disease like cholera.

In studying the history of the last epidemic in the City of Bangkok during the period between December 7, 1919, and September 20, 1920, some interesting facts are presented. Referring to the table we find that the east side of the river is supplied with a pure water and the west side of the river with an impure water. The morbidity and the absolute mortality rates are significantly lower on the east side as compared with the west side, yet we find that the case mortality is higher on the east side than on the west. It might be argued that the greater number of cases would account for this, but in my opinion the reason is to be found in the fact that the people on the east side, having for the past few years used a perfectly

pure water, have lost a certain acquired immunity previously gained as the result of constantly using an infected water supply, while the people residing on the west bank of the river still retain their immunity.

TABLE 1.—*Cholera in Bangkok City.*

[December 7, 1919, to September 20, 1920.]

	East side of river with pure water.	West side of river with impure water.	Total.
Population	603,126	72,610	675,736
Cases	829	684	1,513
Morbidity per 1,000	1.376	9.42	2.23
Deaths	483	360	843
Case mortality ... per cent	58.26	52.63	55.71
Absolute mortality per 1,000	0.800	4.958	1.247

This reasoning is to a degree plausible, although it might be argued that an immunity gained naturally, as the above supposed immunity is theoretically set forth, would be of many years' duration; yet an artificially produced immunity to cholera is of very short duration and may be figured in weeks. Although serum reactions fail to demonstrate the presence of specific immune bodies in the circulating blood, it is not beyond a reasonable doubt that, in spite of such negative evidence, the body does possess a marked degree of resistance to the disease, sufficient at least materially to protect it.

Turning now to another important intestinal water- and food-borne disease, typhoid fever, our experience has been even more impressive. Having the advantage of observing thousands of patients every year as treated in one of the local charitable hospitals, there can be no doubt as to the value of our observation to the effect that during a period of five years only two genuine cases of typhoid fever have been recognized. We feel that our knowledge of the disease and our methods of diagnosis are comparable to those of other workers in the East. Observations of this kind are impressive and cannot but influence one who is a public-health executive in a country not yet willing to accept the primary principles of preventive medicine, let alone the finer administrative details. There is no doubt but that the people have, not in theory only, but in fact also, a marked degree of immunity to typhoid infection. In a series of 600 Widal reactions it was found that 15.5 per cent gave

positive results. From the histories of the entire series of cases it would be impossible to state with any degree of accuracy whether or not any of the subjects had ever had typhoid fever. The information elicited from a native in regard to his previous physical condition is of no practical value; at least that has been our usual experience with the lower-class Siamese. In view of the fact that we have, during a period of five years, observed no less than 35,000 patients with only two genuine cases of typhoid fever being diagnosed, and also that at least 15.5 per cent of all the people (based on 600 reactions) do possess specific immune bodies in their blood, we feel that these people now exhibit a marked degree of racial immunity to typhoid infection. This we think is the result of having for generations suffered from subinfections caused by the constant use of infected water and food.

Among the dysenteries we have found the bacillary types to be comparatively rare. On the other hand, amœbic dysentery is not at all uncommon. This tends to support the above observations. The complications of the disease are uncommon, only four cases of liver abscess having been recognized during the five-year period mentioned.

Of the inoculation group of diseases plague is the most-important epidemic infection we have to deal with. The conditions for its propagation are ideal. There is an unlimited supply of food for the rodent population, and the housing facilities for the same are, as one might say, made to order. Considering the fact that plague has been endemic in the country for many, many years, and in view of the perfection of the conditions for its spread, it is really surprising that there are not more cases each year. From fig. 1 it will be seen that, since 1904 up to and including 1920, there have been only 1,722 cases in a population of over 600,000. From the same graph it will be noted that there is a marked tendency to follow a fundamental wave, the cases increasing in number as well as in severity and extending over a period of from three to four years. The number of cases for 1921 does not appear on the graph, but proved to be one of the lowest that we have had. If this fundamental periodicity is to continue, its recursion is to be anticipated during 1922 or 1923.

Fig. 2 is of interest in showing the relationship between the average monthly incidence, the mean atmospheric temperature, and the mean relative humidity.

As to any racial immunity that the native possesses to the infection it may be stated at once that serum reactions fail to demonstrate specific immune bodies in the blood. However, we feel absolutely assured that, should a European population be

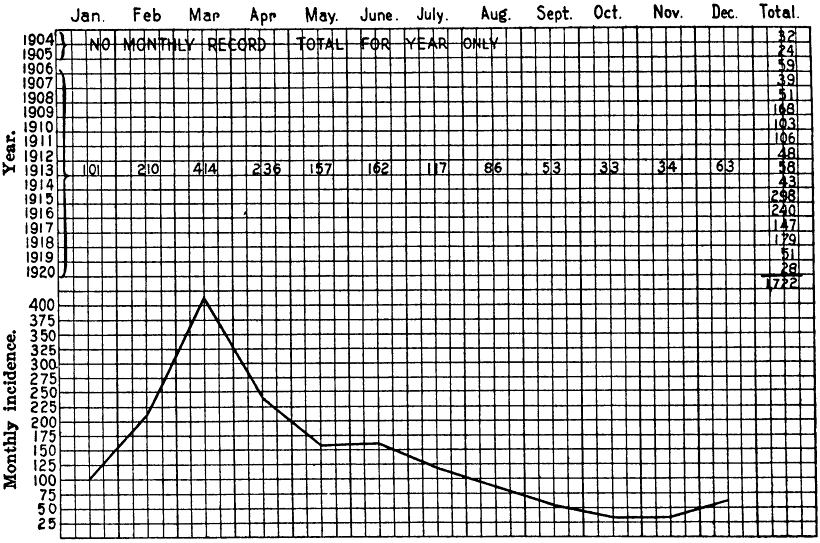

FIG. 1. Notified cases of plague in Bangkok, Siam.

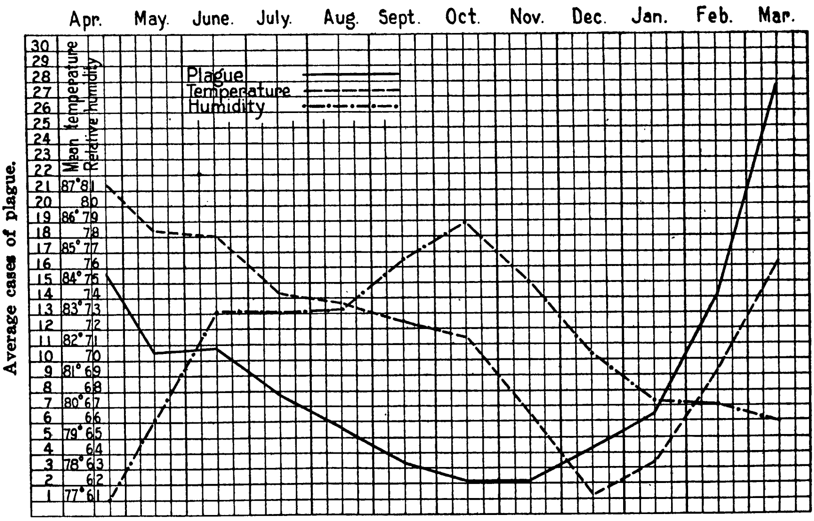

FIG. 2. Average monthly incidence of plague in Bangkok, Siam, during fifteen years, showing also the mean atmospheric temperature in degrees Fahrenheit and the mean relative humidity in percentages.

substituted for the native inhabitants and made to live under native conditions, the European population would be wiped out in a short time as the result of plague. As to some of the other important diseases, I submit the following remarks.

It is hardly proper to mention smallpox as an example of racial immunity, as we have been able to vaccinate a sufficient number of the population to keep it in check. The few cases that do develop in the unprotected are very mild compared to the type of smallpox of which the older physicians in Bangkok speak. The average number of cases per year for the last three years has been thirteen. This is considered an excellent morbidity rate for an eastern city like Bangkok.

We have had in the local general hospital during the last year seven cases of fully developed tetanus with four recoveries. This is of course a small number to cite in support of any theory, yet in the case of a disease like fully developed tetanus we feel justified in recording our experience. We do not feel that it was the treatment that saved these patients; of course, credit is given for the specific effect of the treatment, but it seems almost a certainty that four of these patients with fully developed tetanus could not possibly have recovered had they not possessed a great reserve of what may be termed "general infection immunity."

In one of the institutions under the supervision of the medical officer of health practically all of the emergency surgery for the entire City of Bangkok is taken care of, as well as a large part of that coming from the interior. To cite the number and variety of cases that illustrate, beyond the shadow of a doubt, the fact that these people do enjoy a marked immunity to infection and primary shock resulting from extensive bodily injury is not the purpose of this paper; but in general it may be stated, without fear of serious contradiction, that they can suffer more-extensive injury, and recover from the effects of the same, than is the case with any other people. In the class of cases that come to operation it has been demonstrated that the peritoneum will take care of a very extensive contamination without showing signs of infection. Space permits me to cite but one case that markedly illustrates the reserve these people possess in the way of bodily resistance.

Female patient, aged 32 years, native Siamese. Brought to hospital suffering from extensive stab wounds in abdomen. Injury so extensive that abdominal contents were protruding and wrapped up in an old dirty cloth. Patient several hours previous had been stabbed, wrapped in a

sheet and put into an earthen jar and the same thrown into a canal some 4 to 5 feet deep. Patient managed to escape from sheet and jar and reach the bank of the canal where she was found and brought to hospital.

Half of omentum amputated. Several large intestinal wounds repaired. Protruding abdominal contents washed with normal saline and replaced. Abdominal cavity not irrigated. Abdomen closed with one small drain.

Result, uneventful recovery.

The reader no doubt feels that this is a very exceptional case; but, as a matter of fact, cases of extensive injury and complete uncomplicated recovery are so numerous as to justify taking surgical risks that would not be legitimate in a white person.

Another interesting observation is the comparative lack of syphilis of the nervous system. Primary and secondary syphilis are rampant; but tertiary, and especially nervous, manifestations are so rare as to be absolutely exceptional. We have notes of only two cases of tabes, and in a local asylum for the insane where we have just completed a series of 544 specific serum reactions we find 17.2 per cent positive; yet the medical officer in charge reports that there is not, as far as he is able to recognize, a single case of insanity that can be traced directly to syphilis. This is certainly not due to any difference between the eastern and the western strains of spirochæte, as some authors seem to think. Unfortunately, syphilis of the nervous system is not at all uncommon in Europeans who have contracted their primary infection in Siam.

Of the respiratory group of diseases tuberculosis is, of course, the most important. Of the total deaths reported last year 12.5 per cent were reported as due to pulmonary tuberculosis. This percentage stands to be corrected, as we have been able to demonstrate that from 20 to 25 per cent of cases showing signs and symptoms of clinical tuberculosis are, in fact, either mycotic or spirochæte pulmonary infections. It is surprising that one does not find a greater number of pulmonary infections, considering the crowded quarters that thousands of people occupy. It seems that, given even a small chance, the body is to a very great extent able to overcome the tendency to lung infections. A corrected pulmonary death rate (tuberculosis) of 9.5 per cent is not considered alarming under existing conditions, and we feel quite sure that this rate will gradually reduce itself as sanitary conditions gradually improve. In other words, we feel that it is not necessary to carry on a special tuberculosis campaign if we can educate the masses to a point where they will appreciate and apply a few sanitary and hygienic principles.

Malaria should have been mentioned under the inoculation group of diseases, along with plague, but for a particular reason we wish to call attention to it now. We have been able to demonstrate malarial parasites, or evidence of them, in about 20 per cent of all of the patients attending a large free clinic in one of our hospitals. The subtertian parasite is frequently found, and we have had several cases of genuine quartan, but pernicious symptoms are infrequent. We have seen only eight cases of cerebral malaria; of these, one is a genuine case of multiple neuritis due to malaria. This is a rare and interesting observation. In view of the small number of cases exhibiting severe nervous symptoms it must be recognized that the nervous system of these people is very resistant to attack from the malarial parasite.

In connection with the nervous manifestations of diseases as observed, we wish to call attention to beriberi. This disease is much commoner in the City of Bangkok proper than in the interior of the country, no doubt due to the fact that in Bangkok the people eat fine-milled rice while in the interior the rice used is hand milled. This, of course, is not a new point in support of the deficiency theory as to the etiology of the disease; but another point is to be found, in my opinion, in the prominence of the nervous manifestations of the disease as found in the Siamese. I believe this is due to the fact that, beriberi being a deficiency disease, the nervous system along with the rest of the body must naturally suffer from a lack of vital food elements; whereas, if beriberi were the result of a germ infection, I do not think the nervous system of the Oriental would suffer as it does. We feel justified in advancing this as an important point in support of the deficiency theory as to the cause of the disease, in view of our careful observations regarding the effects of germ infection as a whole and the comparative immunity the Oriental nervous system displays to the same. We must, of course, mention the exception, leprosy, which is admittedly an important violation of the general rule; but we do not think this exception completely vitiates the value of further exploring this important field of investigation.

CONCLUSIONS

1. Specific immunity to typhoid infection can be demonstrated in 15.5 per cent of the people. This is in the nature of a racial immunity, acquired as the result of using, for many generations, an infected water and food supply.

2. Although resistance to certain diseases, such as cholera and plague, cannot be demonstrated by specific blood reactions, it is present in the form of a marked resistance to germ infections as a whole, that is, "general infection immunity."

3. The nervous system of Orientals is much more resistant to the effects of germ infection than is the nervous system of Occidentals.

4. The natural immunity to infection and resistance to disease, as exhibited by the Oriental, is of real value to the health officer working in the East under present conditions.

ILLUSTRATIONS

TEXT FIGURES

METABOLISM IN CHINA

By B. E. Read and S. Y. Wang

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There has not been, as far as we know, a full scientific study of metabolism in China. Hence there are no records of the normal chemical constituents of the urine of the Chinese. Careful analysis has shown that it would be erroneous for the clinician to take the normal percentages given in western books as representing the normal for patients in China, and the two very brief lists of results published by Neale(11) and by Cousland(6) are so limited in character that we have felt it important to go into the matter more fully, making an examination of all the ordinary urinary constituents.

The first study was made upon convalescent surgical patients, who were living on a regular diet, low in protein. The results from diets containing small amounts of protein have been carefully investigated by various workers in recent years.(2) In seeking to try out and subsequently combat Chittenden's dietary standards, McCay,(9) of Bengal, has produced extensive and interesting work on the low protein diet of oriental peoples, showing how such a diet is sufficient to maintain the total protein store of the organism unaltered in amount on a nitrogenous supply that would be much below the amount decomposed during starvation; but he also adds that it is impossible to arrange a diet as low in protein content as Chittenden's standard that will not eventually prove insufficient and unsuitable. The figures in Table 7, for the Bengali students, show how low the amount of nitrogen was. It should be noted that he made no fair estimate of the endogenous metabolism and, with all his extensive food survey, he was unable to say whether or not the diets partaken were correct in character and of sufficient quantity to effect the full endogenous metabolism of a strong, healthy man, for he has no figures for creatinine and relied solely on the amounts of neutral sulphur obtained.

A similar set of results comes to us from Singapore, where J. Argyll Campbell,(3) in his work on the diet, nutrition, and excretion of the Asiatic, states that the results obtained from

the examination of urine indicate that the European figures are of little value when dealing with Asiatic patients. In Table 7 are summarized some of his results which show smaller volumes of urine and lower figures for total nitrogen, chlorides, and phosphates for the Asiatic, as compared with the European. He refers these differences entirely to climatic influence; heat and atmospheric moisture are said to account for the desire to lessen food and work, and the lessening of food brings poor physique and less muscular energy. The students of Singapore,(4) Manila,(1) and the Philippines generally have a smaller protein intake than the European, and this has been accounted for by the fact that climatic conditions require the maintenance of a smaller amount of body heat. Of the three, the Singapore student, with no seasonal change and a mean temperature of 80°, eats the least; but we must observe that his protein metabolism is about the same as that of the Pekingese.

The diet shown in Table 1 represents the average amount of food per diem taken by ten convalescent surgical patients. The actual amount of protein consumed was considerably less, for it was found that the patients did not actually get the amount of meat reported as being served to them. Hence the value of the report lies in the results of analyses of the daily urines. The diet is shown because, except for the amount of meat, the amounts of foodstuff may be considered accurate and show how other factors were taken care of.

TABLE 1.—*Diet of convalescent patients in 1920.*

Foodstuffs.	Breakfast.	Dinner.	Supper.	Totals per diem.
	g.	*g.*	*g.*	*g.*
Bread (wheat) or cooked rice	225	270	270	765
Millet gruel	995	455	455	1,905
Meat	25	25	25	75
Vegetables	100	150	150	400
Oil	15	20	20	55

Foodstuff per diem.	Protein.	Fat.	Carbohydrates.	Calories per diem.
	Per cent.	*Per cent.*	*Per cent.*	
Bread (wheat)	9.2	1.3	53.1	2,014
Gruel	0.86	0.01	5.71	501
Meat	15.6	30.9	----------	260
Vegetables (as cabbage)	1.6	0.3	5.6	126
Oil	----------	100	----------	495
Total	[a]27.26	[b]132.51	[c]64.41	3,396

[a] 105.16 grams. [b] 89.44 grams. [c] 438.73 grams.

EXAMINATION OF URINES

Methods used for making examinations were the following:

Total nitrogen, estimated by Folin's micro method. Micro-Kjeldahl with subsequent Nesslerization.

Urea, soy-bean extract was used. After the action of the urease the ammonia was estimated by Folin's colorimetric method.

Ammonia, by aëration method.

Creatinine, by Folin's picric acid colorimetric method.

Uric acid, by Folin's method.

Chlorides, by Volhard's method.

Sulphates, by barium gravimetric methods.

Phosphates, by titration with uranium acetate.

TABLE 2.—*Summary of urine analyses of convalescent patients.*

Bed No.	Days.	Average volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Creatinine.	Chlorides.	Phosphate.	Total sulphate.	Inorganic sulphate.	Total sulphur.
		cc.		*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*
1	8	2,336	1.019	9.42	5.32	0.784	10.21	1.548	2.034	1.909	2.970
2	4	1,690	1.025	5.12	2.42	0.710	9.75	1.061	1.209	1.051	2.019
3	7	1,674	1.022	5.67	3.13	0.643	7.05	1.322	1.646	1.517	2.583
4	10	1,630	1.021	5.07	2.57	0.452	5.72	0.686	0.842	0.727	1.704
5	5	1.930	1.022	7.32	4.43	1.254	9.18	1.156	1.699	1.571	2.691
6	8	2,341	1.023	10.20	4.93	0.786	7.29	1.324	1.822	1.599	2.699
7	5	1,462	1.025	4.77	1.93	0.765	7.47	1.094	1.387	1.256	1.703
8	6	1,403	1.032	9.07	5.16	1.261	-------	-------	2.164	2.087	3.282
9	5	2,123	1.022	5.68	-------	1.269	7.95	1.299	1.391	1.302	1.858
10	2	1,580	1.020	8.32	6.82	1.744	-------	-------	2.219	2.144	3.305
Average	60	1,817	1.023	7.06	4.08	0.967	8.08	1.186	1.650	1.516	2.481

Table 2 is full of interest as a study of low protein metabolism, it being in accord with other recent work along these lines where workers were able to subsist on as low an amount as 0.5 gram of nitrogen per kilogram of body weight, in wheat, maize, and oats. See the work of Sherman,(13) Rose and Cooper,(12) and many others.

The volumes of the urine excreted were the same as a normal western average. However, as the urines were collected in the winter months, they do not represent an average annual figure. In the summer time the volumes are extremely low.

ANALYSES OF URINES OF NORMAL INDIVIDUALS ON A NONFLESH DIET

Subsequently it was thought advisable to analyze the urines of four laboratory helpers who were in apparently good health,

and dependable for good coöperation in faithfully accounting for everything done. Their diet consisted chiefly of wheat, rice, and beans, and the food value of the average intake amounted to 3,264 calories per day.

The four subjects studied were natives of Peking, of about average weight, namely, a little over 50 kilograms.

TABLE 3.—*Analyses of urines of normal subjects on a nonflesh diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creatinine.	Uric acid.[a]
	cc.		*g.*	*g.*	*g.*	.	*g.*
A	850	1.028	8.820	6.876	0.850	1.264	
A	1,130	1.020	9.413	8.125	0.645	1.255	
A	1,220	1.026	9.211	7.272	1.109	1.499	0.725
A	700	1.027	6.300	4.739	0.672	1.138	
A	1,000	1.032	8.925	7.225	0.778	1.695	
B	730	1.030	9.424	7.764	0.937	1.278	0.667
B	1,150	1.021	9.480	8.439	0.761	1.035	
B	910	1.027	10.010	7.256	0.866	1.265	
B	730	1.023	7.738	5.881	0.569	0.924	
B	700	1.019	5.600	4.376	0.485	1.636	
C	1,150	1.025	7.530	6.026	0.579	0.927	0.582
C	740	1.033	7.622	6.190	0.655	1.010	
C	820	1.024	8.528	6.614	0.766	1.127	
C	1,140	1.024	9.593	7.555	0.695	1.169	
C	970	1.028	8.434	6.916	0.718	0.985	
D	1,130	1.023	9.855	7.381	1.087	1.460	
D	810	1.033	11.907	9.705	0.810	1.472	
D	830	1.045	11.027	7.557	0.783	1.434	
D	810	1.027	10.300	7.537	1.077		
D	960	1.026	11.289	7.856	0.860	1.286	
Average	924	1.027	9.05	7.064	0.761	1.193	0.691

[a] Average of ten determinations each.

ANALYSES OF URINES OF STUDENTS ON A NONFLESH DIET

Six students, taking the ordinary courses of instruction, provided reliable material for further experiments. They were living regularly on a good mixed diet, fairly rich in protein. It was thought to be of interest to compare the results obtained from such subjects when living on a nonflesh diet for a few days with the results from the four laboratory helpers whose regular diet includes no meat except that taken at special holiday times. The total nitrogen, urea, and ammonia values are approximately the same. Values for creatinine as they appear in Tables 2, 3, 4, 5, and 6 show marked differences, indicative of the endogenous metabolism, and to a certain extent a measure of physiological efficiency. One laboratory helper in normal health, but lacking stamina, gave no creatinine in his urine.

He regularly subsisted on a cereal diet. On several occasions hospital convalescents excreted no creatinine in the urine. Examinations were made in the regular manner, care being taken to see that no interfering factor was introduced; also satisfactory controls were made with solutions of known strengths of creatinine.

Statistics regarding students under observation.

	Nationality.	Birthplace.	Age.	Weight.
			Yrs.	*Kilos.*
A	Chinese	Chekiang	25	52.3
B	do	Hupeh	24	66.5
C	do	Canton	24	50.8
D	do	Kiangsu	22	([a])
E	do	Canton	21	41.8
F	do	Chihli	25	([b])

[a] Died. [b] Removed.

TABLE 4.—*Analyses of urines of students on a nonflesh diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creatinine.	Uric acid.
	cc.		*g.*	*g.*	*g.*	*g.*	*g.*
A	880	1.028	8.674	7.655	0.355	1.285	0.229
B	1,800	1.019	9.135	7.753	0.428	1.440	0.490
C	1,170	1.025	9.091	5.994		1.671	0.549
D	1,800	1.015	10.440	8.365	0.905	1.600	0.183
E	1,350		8.181	7.120	0.627		0.471
F	1,100	1.026	9.487	7.050	0.726		0.374
Average	1,350	1.022	9.168	7.323	0.608	1.499	0.382

ANALYSES OF URINES OF STUDENTS ON ORDINARY DIET AND ON A DIET OF AN EXCESSIVE AMOUNT OF MEAT

Further experiments were made with two other diets containing meat, in moderate and in excessive amounts. The terms moderate and excessive refer to Chinese ideas upon this subject. The students were all in good health, taking daily exercise at tennis or other games, and were living upon a normal, middle-class Chinese diet of about 3,500 calories. Such a diet contains a variety of foodstuffs made up into the usual soups and mixed dishes, in which the vitamines and essential proteins are well provided for by many lightly cooked vegetables and various chopped meats. In these experiments it was hoped that we might realize results comparable in nitrogen value to the European standard. However, they more nearly approach the results given by Campbell(3) for Singapore workmen, which he attributes to the heat and the humidity. Our results were

obtained in an exceedingly dry climate, and mostly during winter when snow was falling.

TABLE 5.—*Analyses of urines of students on an ordinary Chinese diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creat-inine.	Uric acid.
	cc.		*g.*	*g.*	*g.*	*g.*	*g.*
A 1	1,410	1.028	13.180	10.760	0.790	1.533	
A 2	1,200	1.029	12.000	10.697	0.727	1.568	
A 3	855	1.033	10.688	8.801	0.697	1.410	
A 4	955	1.030	5.730	4.860	0.445	1.327	
B	1,120	1.021	8.814	7.320	0.689	1.243	
C 1	1,195	1.022	9.321	7.310	0.657	1.195	0.3349
C 2	820	1.033	8.200	6.758	0.626	1.018	0.2534
D 1	1,460	1.027	12.264	10.177	0.773	1.536	
D 2	1,500	1.025	12.495	11.083	0.767	1.685	
E	1,210		9.680	8.260	0.773	1.291	
F	610	1.038	8.134	5.984	0.793	1.140	
G 1	1,500	1.021	11.535	9.853	0.857	1.500	
G 2	1,400	1.020	7.686	5.950	0.777	1.435	
H 1	1,480	1.020	9.546	8.337	0.743	1.396	
H 2	1,370	1.020	6.5713	5.604	0.732	1.556	
Average	1,205	1.027	9.852	8.082	0.727	1.373	

TABLE 6.—*Analyses of urines of students on an excessive meat diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creat-inine.	Uric acid.
	cc.		*g.*	*g.*	*g.*	*g.*	*g.*
A	1,110	1.031	12.130	10.310	0.699	1.655	0.305
B	1,300	1.030	13.728	11.492	0.696	1.898	1.300
C	770	1.031	17.265	15.400	1.091	1.540	0.394
D	1,200	1.026	12.000	10.483	0.857	1.632	0.583
E	950	1.025	12.330	10.156	0.920	1.826	0.468
F 1	1,400	1.022	10.891	7.189	0.861	1.582	0.546
F 2	900	1.032	9.900	7.177	0.833	1.503	0.513
Average	1,090	1.028	12.606	10.308	0.871	1.605	0.587

DISCUSSION OF RESULTS

Total nitrogen.—As observed by Campbell,(4) in all cases the absolute amount of nitrogen was much lower than that of the normal standard for Europe. However, nitrogen equilibrium has been maintained on very much lower values than those of the normal European standard, a number of modern laboratories having worked on vegetarian diets low in protein. The actual values are judged by the amount of total nitrogen per kilogram of body weight. The results from the normal diet of the students is considerably lower than for the European. Taking our average student weight as representing that of the other sub-

jects examined, the values for total nitrogen per kilogram of body weight would appear much lower still; namely, 0.132 for Chinese (Table 2) and 0.169 for Chinese (Table 3). Until further evidence is available we are led to support Campbell's and McCay's view that races who live for generations on low protein diet do not have the physique and energy of those whose diet contains more protein, especially protein from meat. With our present limited knowledge of the exact amino-acid content of our protein foodstuffs, any chance diet low in protein content is not likely adequately to care for the body's needs. The general lassitude of the people; their lack of initiative; their apathy in face of famines and floods, plagues, poverty, and military oppression appear to originate as much in poor diet as in political or educational poverty. Campbell (4) has attributed these defects to the bulk and indigestibility of the vegetable protein food, and to the tropical climate that induces men to work less and to desire less food. The latter factor certainly does not influence the northern Chinese, who experience very cold winters. They are industrious and consume large amounts of cereal food, because there are no good dairy farms to provide better food; and communications are so poor that they cannot look abroad for adequate provision for their needs.

Urea nitrogen.—Neale's (11) observations show the urea nitrogen to be about 21.87 grams in twenty-four hours. His results were based on determinations made by the bromine method, which is so unreliable as to admit of no discussion; the results from this method are usually too high. Our results are in accord with those of Campbell, showing that Folin's (7) estimate of about 79 per cent of the total nitrogen is the normal amount to be expected when the total nitrogen output falls to from 7 to 8 grams. However, our determinations, accurately made upon convalescent patients, show an extremely low percentage (see our discussion of ammonia nitrogen). In any case, no clinician should take the normal European standard as representing a Chinese standard.

Ammonia nitrogen.—Folin (8) observes that, when the total nitrogen excretion is only from 7 to 8 grams, the ammonia nitrogen forms about 5 per cent. Campbell, (5) using Malfatti's method, obtained higher percentages indicative of an acidosis which he attributed to a disturbance of metabolism caused by the hot moist air of the Tropics. In Peking, where the long winters are very cold and dry, we obtained even higher values for ammonia nitrogen. In the case of the convalescent patients

very high results were obtained, undoubtedly due to extreme acidosis.

The excretion of ammonia is regarded as the mechanism whereby the body rids itself of acids formed during metabolism. Some unpublished experiments conducted on urines from osteomalacia cases from Shensi Province show that the subjects had experienced extreme acidosis, causing the bases to be washed out of the system to such an extent that the urine eventually contained very little calcium and the whole structure of the frame was upset. The disease is called locally the acid disease, and is recognized by the lay mind as being related in some way to a disturbance of the acid base equilibrium of the body. Were this disease a rarity it would not call for mention here; but when vital statistics show that 20 per cent of the women of that province die either in or subsequent to childbirth, one is led to attribute the cause to some general factor like an acid-ash diet, injurious to both sexes but more conspicuous in the female. During the long barren winters of northern China the country people subsist on a very limited diet composed almost entirely of cereals. Cereals in general produce an acid ash and may well account for the high ammonia excretion of the Asiatic.

McCay(9) in his studies on Bengali prisoners found very high values; namely, an average of 9.61 per cent of the total nitrogen. In several individual cases, not reported here, very abnormal results were obtained—nearly as high as 20 per cent. Every care was taken to see that no errors were introduced. The urines were preserved, and methods of estimation carried out with normal foreign urines. The results with students' urines, while not quite so high as those for the Bengali prisoners, exceed those for the Chinese students in Singapore. The more-recent work of Campbell(5) on ammonia excretion leaves no room for doubt that the Asiatic has a high ammonia output. His ideas concerning its possible relationship to excessive sweating or to febrile disease are not supported by conditions in Peking; rather, the high output has been considered to originate from the diet, though one often finds intestinal parasites and intestinal disorders that cause putrefaction with a high degree of acidity. Facts concerning such possible causes have yet to be established. If such causes do exist one would look for high values for ethereal sulphates; however, our results show a normal percentage.

TABLE 7.—*Comparative nitrogen excretion of the various races.*

	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.		Ammonia nitrogen.		Creatinine nitrogen.		Uric acid.		Creatinine coefficient.	Total nitrogen per kilogram of body weight.
	cc.		g.	g.	P. ct.	g.	P. ct.	g.	P. ct.	g.	P. ct.		g.
Chinese II; the poor class	1,817	1.023	7.06	4.08	57.7	----	----	0.363	5.05	----	----	----	----
Chinese III; skilled laborers	924	1.027	9.05	7.06	78.1	0.76	8.4	0.448	4.95	0.230	2.54	----	----
Chinese IV; students on non-flesh diet	1,350	1.022	9.168	7.32	79.8	0.61	6.7	0.563	6.15	0.127	1.39	10.5	0.164
Chinese V; students on moderate flesh diet	1,205	1.027	9.852	8.08	81.9	0.73	7.4	0.515	5.22	----	----	9.6	0.176
Chinese VI; students on excessive flesh diet	1,090	1.028	12.61	10.31	81.9	0.87	6.9	0.602	4.78	0.196	1.55	11.2	0.259
Malays in Singapore	(1,335)	(1.010)	8.74	6.89	78.91	0.69	7.91	0.440	5.08	0.170	1.91	7.8	0.154
Chinese in Singapore	(1,273)	(1.012)	8.60	7.02	81.63	0.54	6.28	0.360	4.26	0.140	1.63	8.7	0.208
Bengali students (McCay)	1,200	1.013	6.05	6.04	(?)	----	----	----	----	0.113	1.87	----	----
Bengali prisoners (McCay)	1,570	----	8.84	----	----	0.85	9.61	----	----	----	----	----	----
Europeans (Queensland, Young)	----	----	11.49	----	----	----	----	----	----	----	----	8.52-10.62	0.194
European standard (Halliburton)	1,500	1.020	16.00	13.60	85.00	0.53	3.30	0.570	3.6	0.25	1.56	7-11	0.200

Creatinine nitrogen.—The excretion of creatinine represents chiefly the endogenous metabolism of the body. Hence the coefficient (milligrams per kilogram of body weight) is an important factor. Our results resemble the European standard, though the absolute amounts excreted are far lower. The results, carefully and accurately worked out, are far below anything recorded for normal subjects, either in China or in Europe.

The excretions from vegetarian diets of the Chinese, Tables 2, 3, and 4, give three different average results for the amount of creatinine present in the urine, which on account of the diet is an index of the endogenous metabolism. The excessive flesh diet, Table 6, shows a marked rise in output of creatinine, undoubtedly exogenous in origin. The physique of the three Groups II, III, and IV follows the creatinine values. Group II consisted mostly of coolies or shop assistants in poor condition. Group III, our laboratory helpers, originated from the same class but all have attended school and in their present employment have regular meals, regular work, and leisure to recuperate. The students had the highest excretion, which would be expected on account of their much better physique, better food, regular sleep, and good athletics—all of which factors contribute to make them more fit than the average citizen. The absolute amount naturally increased when the students ate an excessive flesh diet, the increase being of exogenous origin.

It is probably true that, as Campbell(4) points out, the increase in tissue metabolism as judged by a greater creatinine output is not marked in a tropical climate, though it appears to be slightly lowered in our cold northern seasons. Such a deduction is in no way in accord with what would be deduced from the high values obtained for neutral sulphur.

Uric acid nitrogen.—The results in Groups IV and VI are similar, in absolute amounts and in percentage, to those from Singapore. Our values for Group III are abnormally high. This may be due to the drinking of large quantities of Chinese tea. There are no analytical data available to show whether the pale Chinese tea, which is rich in purines, increased the uric acid excretion or not.

Chlorides.—On account of the high price of salt in China, people there do not eat as much salt as Europeans do. Our values are consequently lower. One surgical eye patient, middle-

aged, in apparent good health, excreted no chlorides. He did not dislike salt. After we had administered two 10-gram doses, he excreted it freely in the urine.

Phosphates.—The ratio of phosphoric oxide to nitrogen for the subjects of Table 2 is 1 to 5.1, which is similar to that quoted for Europeans, namely, 1 to 5 or 6.

Sulphates.—The ratio of total sulphur to nitrogen is similar to that obtained by Young.(14) There was an average of 14.06. This is not remarkable when we consider that the ratios obtained vary according to the diet. The absolute amounts of inorganic and ethereal sulphates were fairly normal, indicating no abnormal putrefaction in the intestine; and, since our nitrogen-to-sulphur ratio is high, we conclude that about the normal amount of protein sulphur was oxidized. The proportion of neutral sulphur was very high, see Table 8. Folin(8) has shown how

TABLE 8.—*Excretion of sulphur.*

No.	Total nitrogen.	Sulphur. Percentage of total sulphur.						Nature of sickness.
		Inorganic.		Ethereal.		Neutral.		
	g.	*g.*	*P. ct.*	*g.*	*P. ct.*	*g.*	*P. ct.*	
1	9.42	1.909	64.3	0.125	4.21	0.936	31.5	Hernia and chest.
2	5.12	1.051	51.8	0.158	7.77	0.810	39.8	Multiple abscesses.
3	5.67	1.57	58.6	0.128	4.99	0.937	36.2	Wound in foot.
4	5.07	0.727	42.6	0.115	6.75	0.862	50.6	Septic leg.
5	7.32	1.571	58.4	0.128	4.75	0.992	36.8	Necrosis of tibia.
6	10.20	1.599	59.3	0.243	9.03	0.877	32.5	Tuberculosis in knee.
7	4.77	1.256	73.8	0.131	7.70	0.316	18.5	Tuberculosis of spine.
8	9.07	1.087	63.6	0.077	2.34	1.118	34.06	Gangrene of foot.
9	5.68	1.302	70.2	0.089	4.60	0.467	25.2	Spur of os calcis.
10	8.32	2.144	64.9	0.075	2.26	1.086	32.84	Scoliosis.
Average	7.06	1.516	61.16	0.125	5.04	0.840	33.0	

the amount of neutral sulphur excreted is practically independent of the diet. In his experiment a patient on a normal protein diet gave 0.18 gram, or 4.8 per cent of the total sulphur, and the same person on a reduced protein diet gave 0.2 gram, or 26.3 per cent of the total sulphur. It is a known fact that anæsthetics will increase the amount of neutral sulphur; however, not all of our patients were operated upon, but all show high values. In any case, none of the urines were collected until the patients were well on the road to recovery and convalescing, just before being discharged. Case 4, which gave an average

of 50.6 per cent from duplicate determinations on ten successive days, is noteworthy. The determinations were made up to the day the patient left the hospital. It is thought possible that, as the Chinese are exceedingly fond of garlic, onions, and cabbage these foods may be related in some way to this exceptionally high excretion of neutral sulphur.

SUMMARY

1. Analysis of the chemical constituents of Chinese urines excreted by various classes of people taking different diets has been made.

2. The results have been compared with those obtained for Europeans, subjects of India, Asiatics in Singapore, and Europeans in Queensland.

3. The absolute quantities of nitrogen and urea are low, being similar to the results obtained by Campbell(4) for Asiatics in Singapore. He attributed these low results to the indirect effects of heat and humidity. Our results were obtained in a dry cold season, and we consider diet to be the sole reason for such low results.

4. The percentage of ammonia nitrogen is far above the European normal but agrees exactly with Campbell's(5) and with McCay's(10) findings. Disregarding climate, we believe high cereal diets to be the cause, or it may be a racial characteristic.

5. The Chinese do not excrete large amounts of chlorides. Bunge's theory that vegetarian diets produce a greater craving for salt can be ignored in a country where goverment monopoly makes salt a luxury.

6. Values obtained for neutral sulphur were very high. Young,(14) of Queensland, obtained similar results, from which he declined to draw any definite conclusions. We again suggest dietary causes, introducing an exogenous rather than an endogenous factor.

7. Our results in general confirm those of others working on Asiatic subjects. The environments being so different we conclude that heat and humidity are not the controlling factors.

8. Definite conclusions concerning the seeming abnormalities of Asiatic metabolism are deferred until abundant data have been collected from a variety of sources in the Orient.

9. Clinicians working in the Orient should adjust their standards in chemical analysis accordingly.

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A NEW GENUS AND SPECIES OF FLY REARED FROM THE HOOF OF THE CARABAO

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Genus BOOPONUS [1] novum

Female only.—Eye rather small, bucca (below) equal to half its height; front one-third of head width, the median stripe occupying two-thirds its width. Ocellar bristles well developed, strongly divergent; verticals two pairs, the inner convergent. Frontal bristles about fourteen in the row, reaching the middle of second antennal joint, the uppermost one diverging strongly to the side, the next just as strongly to the middle, and the following ones like it but gradually more erect. Interfrontals absent. Two small orbitals placed high up, opposite second and third frontals. Outside the frontals a uniform covering of small black hairs, which extend downward covering the parafacials and bucca except a small space outside of and above the vibrissæ. Facial ridges with larger hairs nearly halfway up. Vibrissæ hardly more than half as far apart as the facial ridges at their middle. Face much depressed, the ridges high and sharp. Antennæ of ordinary form, not large. Arista strongly thickened on basal two-fifths, penultimate joint short, bare below, pectinate above with short hairs which at longest are hardly double the thickness of the arista. Palpi normal; proboscis short, with ordinary labella.

Thorax with a row of half a dozen hypopleural bristles; sternopleurals, 2; acrostichals, 2 or 3 anterior, 3 posterior; dorsocentrals, 2, 3; humerals, 3; interhumerals, 1; posthumerals, 2; presuturals, 2; notopleurals, 2; intra-alars, 3; supra-alars, 2; postalars, 2; scutellars, 4 pairs lateral in a straight row of which the last and largest is apical, and 3 or 4 pairs above them which become subdiscal toward the tip. Hind calypter bare, twice as wide as front one. Pteropleura with hairs and a very small bristle.

Abdomen without macrochætæ, covered with uniform black hairs like those on the head; hind edge of all four segments

[1] Βωυς, the ox; κωνως, affliction, torment.

with a row of longer hairs, not conspicuous. Sternal plates uncovered.

Legs weakly bristled; mid-tibia at last fourth with one small bristle on inner side and one on outer front; on the outer hind are two small bristles.

Wing with first posterior cell narrowly open almost in the apex, the third vein bearing nine or ten setules at base, its last segment bulging forward in and beyond the middle, then curving backward; fourth vein with a broadly rounded double curve, near tip becoming almost parallel with third; no costal spine.

As far as can be judged from a female, the genus is somewhat allied to *Cordylobia*, but differs in having the arista not plumose, etc. I can find no genus of testaceous flies with an arista like the one here described. The three specimens examined vary in regard to the third pair of anterior acrostichals, which when present stand just in front of the suture; one specimen has them present, one absent, and in the third a single bristle is present, its mate absent. This character is generally of importance, as Villeneuve has used it to separate his Xanthocalliphorinæ (his Testaceæ sens. str.) from Eucalliphorinæ (*Calliphora* etc.).[2]

Booponus intonsus sp. nov.

Female.—Wholly light yellow, including tarsi, except a trace of brownish on the anterior part of the thoracic dorsum. Front 0.32 of the head width. Wings subhyaline with yellow veins. There are numerous short, evenly placed black hairs, not only on the front, face, and bucca (suggesting the specific name), but also on the femora and whole abdomen, and even interspersed with the bristles on the mesonotum and scutellum.

Length, 6.3 millimeters.

Described from three female specimens reared at Los Baños, Laguna Province, Luzon, from the hoof of the water buffalo.

Type, female, catalogue No. 25646, United States National Museum.

[2] Bull. Soc. Ent. France No. 14 (1920) 223–225.

THE FOOT MAGGOT, BOOPONUS INTONSUS ALDRICH, A NEW MYIASIS-PRODUCING FLY

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EIGHT PLATES

In the routine work of laboratory diagnosis on the cases in the clinic of the College of Veterinary Science of the University of the Philippines, a peculiar type of myiasis-producing fly was discovered. From clinic case 109 (carabao) a number of maggots were obtained which were strikingly different, both in appearance and in habit, from the other types of fly larvæ which had been previously observed. Adults raised from these maggots were forwarded to Dr. J. M. Aldrich, of the Smithsonian Institution, through Dr. L. O. Howard, chief of the Bureau of Entomology of the United States Department of Agriculture. Doctor Aldrich reported the fly to be a previously undescribed species, and one for which a new genus must be erected. It has since been described by him as *Booponus intonsus*.[1] Subsequent to the recognition of this distinct type of myiasis, several interesting cases have been treated in the clinic of the College of Veterinary Science, which have furnished excellent oportunities for a detailed study of this peculiar fly.

CASE REPORTS

1. *Case 109, February 16, 1922.*—Carabao, female. History of a previous attack in 1920 with maggots in the feet. Animal lame. All four feet affected. Foot maggots found in many of the puncture wounds. About one hundred taken from the four feet, the heaviest infestation in the hind feet.

Treatment.—Removed as many of the maggots as could be found and applied a chloroform pack to each foot for twenty-four hours. Eleven

[1] Antea, p. 141.

dead maggots found when pack was removed. Tar and sulphur ointment applied daily for three weeks. Skin wounds healed by that time, and the horn of the wall grown so that the holes that had been at the top were no longer in soft tissue. No more maggots being found treatment was discontinued and the animal kept under observation. Thirteen days later seventeen larvæ were found, one in each of the front legs and the rest in the hind legs. Same treatment as given before was given for two weeks and the case discharged as cured. A month later the animal was brought back to the clinic, having become reinfested. As the animal could not be left in the clinic, the maggots were removed and the caretaker was given a supply of tar ointment to apply daily.

2. Case 121, March 12, 1922.—Hereford, male. In hospital for myiasis of the external ear. Was kept in the same paddock with case 109. On April 1, 1922, the animal was observed to be lame in the left hind leg. Foot maggots found in the affected limb. At the juncture of the skin and horn a large larva was found half buried in a very small puncture wound.

Treatment.—Chloroform pack twenty-four hours, and daily application of the tar ointment for eight days. Animal completely recovered.

3. Case 146, April 2, 1922.—Hereford, male. Brought to the clinic with a history of lameness. Foot maggots found in the left hind foot.

Treatment.—Same as for case 121. Discharged as cured on April 8, 1922.

4. Case 182, May 15, 1922.—Hereford, male. Animal brought to the clinic with an abscess in the right flank. The feet were examined and four foot maggots found in the right hind foot.

Treatment.—An ointment made up of sulphur, 1; oil of tar, 2; sodium bicarbonate, 1; and wool fat, 8, was applied daily. Foot lesions cured in six days.

5. Case 220, June 24, 1922.—Hereford, female. Foot maggots found in all four feet.

Treatment.—Maggots removed and the ointment used in case 182 applied daily for three days. No treatment given the next two days. On June 29 a few small maggots were found in each of the four feet. Ointment again applied daily until July 4. Case discharged as cured on July 7, 1922.

6. Case 225, June 29, 1922.—Carabao, female. While inspecting the carabaos of the College of Agriculture for traces of previous infestations with foot maggots, one of the milking herd was discovered to be very restless and was sent to the clinic for examination. Many foot maggots were found in both hind feet.

Treatment.—Same as for case 182. The following day six small maggots were taken from the left hind foot, eight from the right hind foot, and one from the right front foot. Treatment continued, and no more maggots found. Case discharged July 4, 1922. Caretaker supplied with the ointment with instructions to apply daily. No reinfestation occurred.

7. Case 250, July 11, 1922.—Hereford, male. Brought to the clinic with a scrotal wound infested with screw-worm larvæ. Feet examined, and foot maggots found. Many eggs of the foot-maggot fly found attached to the hairs about the fetlock.

Treatment.—All maggots found were removed, and the hair was clipped short from the pasterns and fetlocks. Ointment as used for case 182

applied. Several dead larvæ removed the following day. Ointment then applied daily until July 18, when treatment was discontinued. Animal remained in the clinic until August 10, under observation, no recurrence of the condition taking place.

8. Case 251, July 11, 1922.—Hereford, male. History of lameness in the right hind leg, and larvæ in the foot. Had previously received treatment, consisting of chloroform pack and bandage. Two foot maggots found in the affected limb.

Treatment.—Same as for case 182. Discharged on July 13.

9. Case 252, July 11, 1922.—Hereford, male. History of lameness in left hind leg. A deep wound found ventral to the lateral claw of affected leg; also numerous puncture wounds at coronary band and at margins of claws of all four feet. More than one hundred foot maggots removed.

Treatment.—From the fetlock down the hair was cut short to remove fly eggs. Same ointment applied daily as in case 182. On the 16th a heavy application of pix liquidæ applied. No further treatment given. Animal under observation until August 1, with no reinfestation.

10. Case 259, July 13, 1922.—Hereford, male. History of lameness. Approximately eighty foot maggots and one screw-worm fly larva found.

Treatment.—Same as given to case 182. Discharged with feet in good condition on July 18.

11. Case 260, July 14, 1922.—Hereford, male. Brought to clinic with a wound in the prepuce infested with screw-worm larvæ. Feet found to be infested with foot maggots. Small puncture wounds present in the following numbers and locations:

48 in coronary band, right hind foot, of which 27 were at bulbs of heels.
19 around lateral dew claw, right hind foot.
18 around medial dew claw, right hind foot.
57 in coronary band, left hind foot, of which 43 were at bulbs of heels.
22 around lateral dew claw, left hind foot.
21 around medial dew claw, left hind foot.
29 in coronary band, right front foot.
19 in coronary band, left front foot.

Treatment.—Maggots removed, hair closely clipped, and a heavy coating of pix liquidæ applied. Three days later the application was repeated. No further treatment. Animal under observation until August 5. No reinfestation.

12. Case 298, July 24, 1922.—Goat, male. Sent to clinic for castration. Animal lame in right front leg. One large foot maggot found burrowing into tissue at the lateral surface of the carpus. Foot maggots also found at the coronary band of the feet in the following numbers:

3 in left front foot.
2 in right front foot.
5 in left hind foot.
3 in right hind foot.

Treatment.—Same as for case 121. Foot lesions cured July 31, 1922.

13. Case 299, July 24, 1922.—Goat, male. Sent to clinic for castration. Twelve foot maggots found in feet. All four feet affected.

Treatment.—Same as for case 121. Foot lesions cured in eight days.

14. Case 302, July 24, 1922.—Hereford, male. Sent to clinic with *Otitis externus*. Fourteen foot maggots found; all four feet affected.

Treatment.—Same as for case 260. Foot lesions healed in seven days. Still under observation.

15. Case 318, July 26, 1922.—Hereford, male. In clinic for an abscess in right costal region. Foot maggots in left hind foot.

Treatment.—Same as for case 121. Foot lesions cured August 7.

16. Case 319, July 26, 1922.—Goat, female. Animal weak, depressed. Left front foot gangrenous as high as carpus. Heavily infested with screw-worm larvæ. A few foot maggots present.

Treatment.—Leg amputated above the carpus. Animal died shortly after operation.

17. Case 321, July 26, 1922.—Goat, female. Large gangrenous wound at the fetlock, right hind leg. Foot maggots and screw-worm larvæ present.

Treatment.—Necrotic tissue removed and a chloroform pack applied. Following day, treated with a 10 per cent silver nitrate solution, and from then on received ordinary wound treatment. Discharged as cured August 23.

18. Case 322, July 28, 1922.—Hereford, male. History of lameness. All four feet found infested with foot maggots:

4 at coronary band, left hind foot.
5 at lateral dew claw, right hind foot.
7 at bulbs of heels, right front foot.
2 at bulbs of heels, left front foot.

Treatment.—Chloroform pack, painted with pix liquidæ every third day until discharged as cured August 3.

19. Case 324, July 28, 1922.—Hereford, male. All four feet infested with foot maggots.

Treatment.—Maggots removed and pix liquidæ applied every other day until discharged as cured on August 3.

20. Case 361, August 10, 1922.—Goat, female. Large gangrenous wounds at fetlocks of both hind feet. The right foot had been disarticulated at the fetlock by the maggots. Foot maggots and screw-worm larvæ present. Animal died before treatment could be given.

BOOPONUS INTONSUS ALDRICH

LIFE HISTORY

Egg.—Elongate ovoid, with the anterior end somewhat pointed. Dull grayish white. Attached to the hairs of the host by means of a membrane formed by a gelatinous secretion of the female at the time of oviposition. Somewhat flattened on the side of attachment, the anterior or more-pointed end placed toward the base and closely applied to the hair. Smooth except for a band of small punctures on the outer or dorsal surface on the median line. Average measurements: Length, 0.875 millimeter; breadth, 0.229 (Plate 2, figs. 5 and 6).

Young larva.—The young larva resembles the full-grown larva, but differs in that the body spines are much darker and there are but two slits in each of the posterior stigmata (Plate 4, fig. 1).

Full-grown larva.—Body plump, robust, cylindrical; wedge-shaped when fully extended (Plate 1, figs. 1 and 4). Posterior

end rounded and invaginated, with one very small pair of tubercles dorsad, another pair ventrad, and a third pair lateroventrad of the stigmata (Plate 1, fig. 7). Body grayish white, lateral fusiform areas absent, ventral areas present. Body surface covered with irregular rows of short, stout, reclinate, pale brown spines (Plate 1, fig. 6). Head retracted into thorax when at rest, bilobed, with a pair of minute, sometimes faintly pigmented papillæ anteriorly and a brown chitinous comb ventrobasally on each lobe (Plate 1, fig. 8; Plate 3, fig. 1). Oral hooks two, toothed, dark brown to black, and recurved ventrally (Plate 2, fig. 2). Amphipneustic. Anterior spiracular projections swollen, with tubercular surface, trachea (visible through the projections) with 18-digitate extremities (Plate 1, fig. 5; Plate 3, fig. 1). Posterior stigmal plates on swollen hemispherical areas on the sides of the invaginated region of the posterior end of the last abdominal segment (Plate 1, fig. 7). Slits three, subparallel, with serrate edges (Plate 1, figs. 2 and 3; Plate 4, fig. 2). Length, 8.5 to 10 millimeters; breadth, 2.5 to 3.

Puparium.—Regularly ellipsoidal, rich chestnut brown to black (Plate 2, fig. 3). Surface finely rugose, with very short recumbent spines except for small bare areas along the segmental sutures which serve to accentuate the segmentation. Anterior spiracular projections protruding and tuberculous (Plate 2, fig. 4); posterior stigmal plates slightly swollen, black, with the same general appearance of the anal stigmata of the full-grown larva. Size variable, average length, 6 to 7 millimeters; breadth, 2.25 to 2.75.

Adult.—For description of the adult stage,[2] the reader is referred to the original description of Aldrich (antea, p. 141).

HABITS

Oviposition.—Occasionally the adults may be seen hovering around the legs of carabaos and bullocks. They alight on the lower portions of the leg and deposit their eggs on the hairs of the host. A gelatinous material secreted by the female at the time of oviposition serves to attach the egg to the hair (Plate 2, fig. 6). Almost invariably the eggs are placed head downward. As many as four eggs on one hair have been noted. More commonly only one egg is found on a single hair, and it is usually

[2] It is interesting to note that although some forty adults have been reared from the several different cases, only females have so far been obtained.

placed at about the middle. Eggs are deposited on the lower portions of the legs, principally between the toes and at the heel under the dew claws, less commonly up as high as the knee.

Hatching.—The young larva emerges from the egg by cutting a small circular flap on the dorsal surface of the anterior end of the egg (Plate 2, fig. 5). The incubation period varies considerably, possibly dependent upon certain stimuli which the egg may receive under conditions favorable for the young larva to become established in the host. Under laboratory conditions eggs hatched in from three to five days.

Young larva.—The young larvæ emerge from the egg headed toward the base of the hair. They work their way down the hair and then down the leg to the coronary band. Whether they attempt to enter the flesh at places other than that of the region of the coronary band is not known, but the presumption is that such is the case. In two cases, foot maggots have been found infesting regions other than that of the coronary band. Both of these were goats, animals whose skin is comparatively thin and tender. In these animals, both the coronary region and the knee were infested. In all other cases only the coronary region was involved. In all of the host animals, the tenderest part of the leg is the bulb of the heel, and the heaviest infestations are always found there. From these facts and from observations on newly hatched larvæ it seems safe to say that the larvæ attempt to enter the flesh at the point at which they happen to be when hatched, or they wander around searching until they find a place to enter or are brushed off or die. Because of the softness of the tissue of the coronary region, especially around the heel, the larvæ that survive and reach that region are able to enter and bury themselves in the flesh. Evidently the young larvæ enter the flesh before the third pair of slits is formed on the posterior stigmal plates, for no specimens with three pairs have been observed outside the tissue of the foot, and many that have but two pairs have been dug out of the flesh.

The maggots bury themselves in the tissue nearly parallel to the surface, leaving their posterior end exposed. The entrance holes are simple and small (Plate 7, figs. 1, 3, and 4), and once in the flesh the larvæ do not move around to any appreciable extent.

Full-grown larva.—The length of the larval period is not definitely known. From case histories and reinfestations, it appears that the period probably ranges from two to three weeks.

The full-grown larvæ leave the flesh and drop to the ground, where they bury themselves and pupate. The great variation in size of pupæ seems to be a direct result of the amount of available larval food. The pupal period is approximately ten days. The imago escapes from the pupa case by splitting the operculum, or cap, on the median line, and pushing the two halves aside as flaps.

OCCURRENCE AND ABUNDANCE

Adult.—The adult flies have not previously been observed. The genus and species were described from specimens reared from infested animals on the campus of the College of Agriculture at Los Baños, Laguna Province. Since the first breeding was made, a few adults have been observed depositing eggs on the feet of a carabao kept at the Forest School at Los Baños. No further records of its occurrence or abundance are extant, nor were specimens of the fly present in the collections of the College of Agriculture, the Bureau of Science, or the private collection of Prof. C. F. Baker, previous to its discovery. From the fact that the region around Los Baños is perhaps better known entomologically than any other in the Islands, it would appear that the fly is comparatively rare. Cases of myiasis produced by the maggots, however, tend to show that such is by no means the case.

Larva.—Twenty cases of myiasis caused by this fly subsequent to its recognition, have been recorded in the clinic of the College of Veterinary Science at Los Baños. Previous to that time there were undoubtedly other cases, but they were probably confused with myiasis produced by the screw worm, *Compsomyia dux* Eschscholtz, a very common and harmful pest of stock in the Philippines. The effects of infestations of the foot maggot are quite definite and distinctive. From these effects it has been possible to gather some data on the relative abundance of infestations. The college herds were examined, with the results indicated in Table 1.

TABLE 1.—*Showing incidence of foot-maggot infestations in the animals of the College of Agriculture.*

Hosts.	Positive.	Negative.
Work bullocks and Nellores	3	14
Milk animals (carabaos)	3	3
Carabaos	9	4
Herefords	12	3

Veterinary students reported the prevalence of the disease in the various barrios of Los Baños as shown in Table 2.

TABLE 2.—*Showing incidence of foot maggots among animals in Anos, Malaquing Bato, Maahas, and San Antonio Barrios.*

Hosts.	Positive.	Negative.	Attacked.
			P. ct.
Carabaos	13	11	54
Native cattle	5	36	12
Goats	0	8	0
Total	18	55	25

All of the Filipino farmers in different parts of Laguna Province, to whom foot-maggot cases or the characteristic after effects were shown, have stated that the condition is a rather common one and that often animals are laid up from lameness due to maggots, *uod*, in the feet.[3] From their descriptions of the infestations and from the fact that they recognized the hoof injuries resulting from such infestations, it is presumed that the cases at the College of Agriculture cannot be considered either unique or endemic. A further fact, brought out in conversations with owners of stock in Laguna Province, was that the number of cases was greatest in the dry season, and this checked with observations made by us on the college herds. This seasonal occurrence may be explained by the fact that during the wet season the animals spend a greater part of their time in mud and water. The mechanical action of the mud would tend to remove the larvæ and, perhaps, the eggs. The flies would also have greater difficulty in depositing the eggs. Actually, eggs are much more difficult to obtain in the rainy season. Further, Hereford cattle are much more susceptible to the attacks of the fly than are carabaos. Carabaos will wallow in mud at every opportunity, while Herefords are essentially dry-pasture animals. Still further evidence is offered in the case of the carabao owned by the Forest School of the Bureau of Forestry. This animal has had a continuous series of infestations throughout the dry season. No animal in the college herd has had a comparable amount of trouble from this pest. The Forest School carabao, however, never wallows in the mud, there being no facilities for this at the Forest School, while the college animals are pastured

[3] We are informed through Dr. Miguel Manresa, of the College of Veterinary Science, that there is a local word, *kayuko*, which refers to this particular myiasis. The use of the term appears to be quite local.

in fields with plenty of wallows and the animals can soak themselves at will.

HOST ANIMALS

So far only Bovidæ have been recorded as hosts. Maggot specimens have been obtained from Hereford, Nellore, and Philippine cattle, carabaos, and goats. Data available are not sufficient to allow the drawing of definite conclusions relative to the susceptibility of the various kinds of animals. However, in the vicinity of Los Baños the order of percentage of attack observed is: Hereford cattle, carabao, Philippine and Nellore cattle, goats.

DIFFERENTIATION BETWEEN SCREW WORMS AND FOOT MAGGOTS

The common screw worm of the Philippines, *Compsomyia dux*, differs from the foot maggot in several very obvious details. Because the former is the maggot most likely to be confused with the foot maggot, descriptions of the larval and pupal stages are included in this paper.

COMPSOMYIA DUX ESCHSCHOLTZ

Larva.—Body elongate, regularly tapering and wedge-shaped. Posterior end truncate. Body yellowish white. Anterior margin of each segment swollen and with several irregular rows of short, stout, reclinate spines. Head bilobed, with a pair of blunt tubercles, one above the other, on each lobe (Plate 3, fig. 2). Oral hooks two, toothed, dark brown, and strongly recurved ventrally (Plate 2, fig. 1). Segments 5 to 10 with lateral, spinulose, fusiform areas against the anterior margin of the following segment. Segments 6 to 11 with narrow, transverse, smooth, fusiform areas on the somewhat broadened ventral part of the swollen spinulose anterior rings. Amphipneustic. Anterior spiracles probably not functional, indistinct, consisting of a row of six small circular openings. Posterior stigmal plates approximate, situated at the bottom of a deep cavity at the posterior tip of the body. Slits three, subparallel, without button, and chitinous process not completely inclosing them. Ten small tubercles on the edge of the stigmal cavity (Plate 5). Segment 12 with a swollen spinulose area ventrally which is bisected transversely by a smooth area and gives rise to two, large, widely separated tubercles. Length, 12 to 12.5 millimeters; breadth, 3.5 to 4.

Puparium.—Regularly ellipsoidal, chestnut brown to black. Surface finely rugose, with recumbent spines located as in larva. Anterior spiracles not apparent. Posterior stigmal plates not sunken, but otherwise as in larva. Size variable. Average length, 10 millimeters; breadth, 3.

Distinguishing characters.—Screw-worm infestations are usually secondary. The adults are attracted to open wounds and blood, and the larvæ enter the flesh through the broken skin. In a few cases, crushed engorged ticks or drops of blood from tick bites or horsefly bites are the attraction for the screw-worm fly, and myiasis may occur at those points without previous abrasion. Screw worms are often found in feet previously injured by foot maggots. Foot maggots, on the other hand, usually occur as primary pests.

Screw-worm infestations may occur on any part of the body, while foot maggots are apparently confined to the coronary region of the tougher-skinned animals, and have been found as high up the leg as the knee in the tenderer-skinned animals, such as goats. Again, foot maggots appear to be confined to the Artiodactyla, while screw worms attack all mammals.

The larvæ may be easily distinguished by the characters noted in Table 3.

TABLE 3.—*Showing distinguishing larval characters of the screw worm and the foot maggot.*

Character.	Screw worm.	Foot maggot.
Shape	Cylindrical, wedged-shaped when at rest.	Plump, robust, more or less ellipsoidal when at rest.
Surface	Each segment with but a few irregular rows of spines on the anterior half.	Entire surface of each segment with irregular rows of spines.
Posterior spiracles	With a heavy chitinous ring around the slits. Stigmal plates approximate.	Without heavy chitinous ring. Stigmal plates separate.
Anterior spiracles	Indistinct, with six openings.	Conspicuous, with eighteen openings.
Color	Yellow-white.	Grayish white.
Posterior stigmal invagination	Surrounded with ten tubercles.	Surrounded with six tubercles.

SUMMARY

The eggs of the foot maggot are laid on the hairs of the lower extremities of the legs of the host animals. The larvæ work their way down to the skin and attempt to enter the flesh. In the tougher-skinned animals, they are unable to enter at any

place other than the coronary region of the foot. The increase from two to three slits in the posterior stigmal plates of the larva takes place while the larva is buried in the flesh. The injury by the foot maggot is primary, but is often followed by serious secondary infestations or complications. The fully developed larvæ leave the foot and enter the soil for pupation.

Cases of foot-maggot myiasis and observations on animals tend to show that the fly is neither rare nor local. In the past it has evidently been confused with the screw worm. Circumstantial evidence shows that the habits of the host animals have a direct relation to their susceptibility. Seasonal occurrence of the insect is dependent, to some extent, upon the same factors that control its relative abundance on its various hosts.

The host animals appear to be confined to the Bovidæ, or at least to the Artiodactyla. So far only Bovidæ have been definitely proven as hosts.

Symptoms.—A lameness, that varies in degree, is usually the first indication of foot-maggot infestation. The animal is restless and shakes the affected limb. It is often observed raising the leg and licking the infested area. If all four feet are involved the animal will assume a recumbent position at every opportunity.

Numerous small puncture wounds are found in the skin at the coronary band, and in the soft horn at the dorsal border of the horn wall of the large claws. The bulbs of the heels are usually the most heavily infested (Plate 7, figs. 1, 3, and 4). Wounds of the same type are also found at the margins of the small claws. When the larvæ are numerous, the area affected exhibits a honeycomb appearance. These wounds are superficial, and do not extend into the underlying structures. However, they offer an entrance for infection and secondary infestation with screw-worm larvæ (Plate 7, fig. 2). Infection is practically always present in cases of long standing, and then the amount of tissue destruction assumes serious proportions.

As a sequel to the destruction of the coronary band and of the soft horn, many small transverse cracks and crevices are found in the horn wall extending as low as the ground border (Plate 8, figs. 1, 2, 3, 4, and 5). The transverse rings are also distorted.

Prognosis.—Favorable, providing treatment is given early to prevent complications.

RECOMMENDATIONS

Treatment.—From the results observed in the treatment of clinic cases and from the knowledge of the habits of the fly itself, the following treatment is considered most efficient. Clean the affected area with soap and water. To get rid of the fly eggs, closely clip the hair from around the feet. Remove as many of the maggots as possible and apply a chloroform pack for twenty-four hours. This should be followed by heavy applications of pix liquidæ every third day until the lesions heal. The chloroform pack can be dispensed with provided the infestation is of so recent occurrence that the pix liquidæ can be applied directly to the maggots.

Prevention and after treatment.—All cattle, carabaos, and, possibly, goats should be inspected daily, especially during the dry season, to prevent this type of myiasis from spreading throughout the herd, and also to start early treatment of the affected animals. Inspection is not difficult as the condition is easily recognizable. During the dry season it is important that the animals have access to plenty of water, as the mud on their legs makes it difficult for the fly to attach its eggs.

ILLUSTRATIONS

PLATE 8

FIG. 1. Anterior view of left fore foot of carabao, showing foot-maggot injury.

2. Anterior view of left hind foot of carabao, showing foot-maggot injury.

3. Posterior view of left hind foot of carabao, showing foot-maggot injury to dew claws.

4. Lateral view of left fore foot of carabao, showing foot-maggot injury.

5. Lateral view of right hind foot of carabao, showing foot-maggot injury.

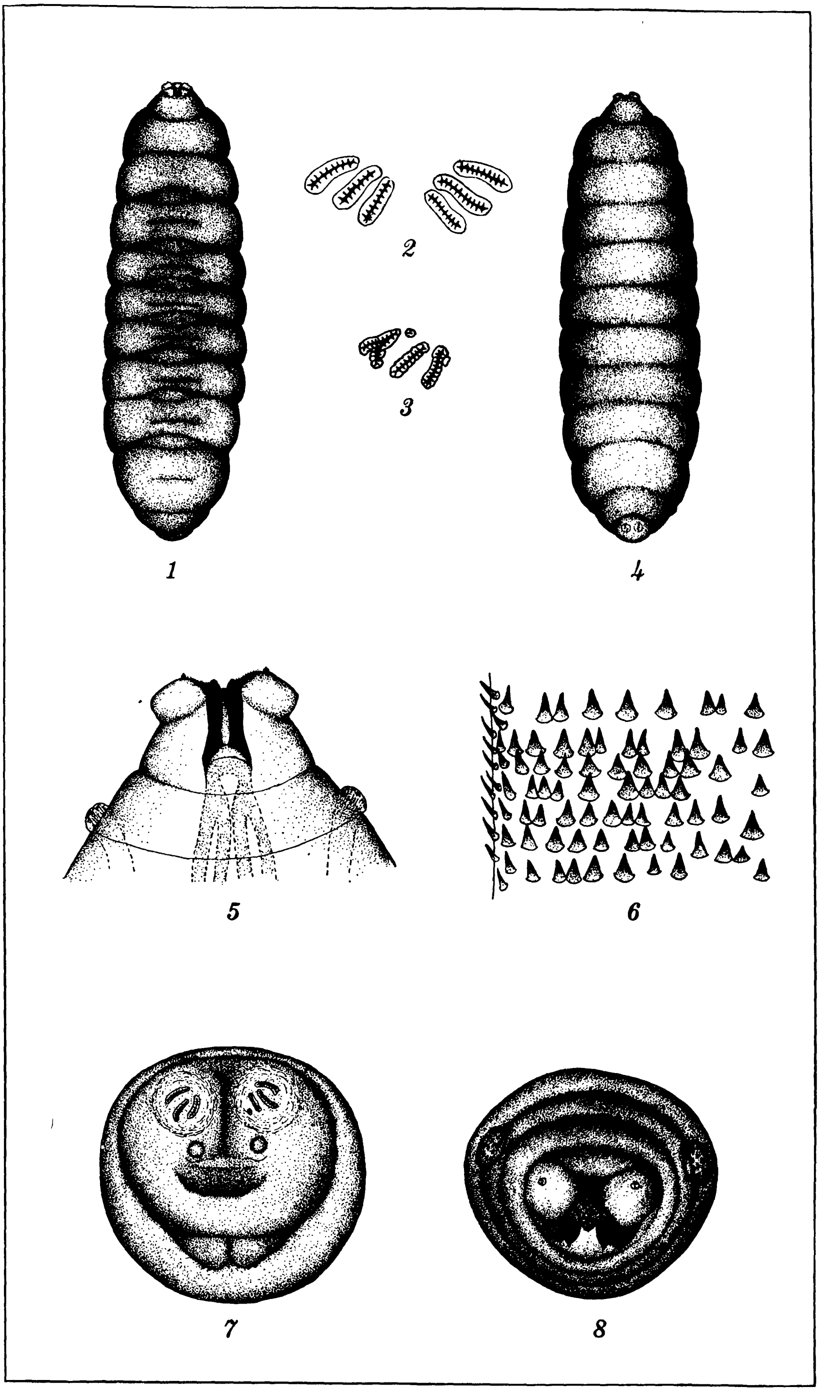

PLATE 1.

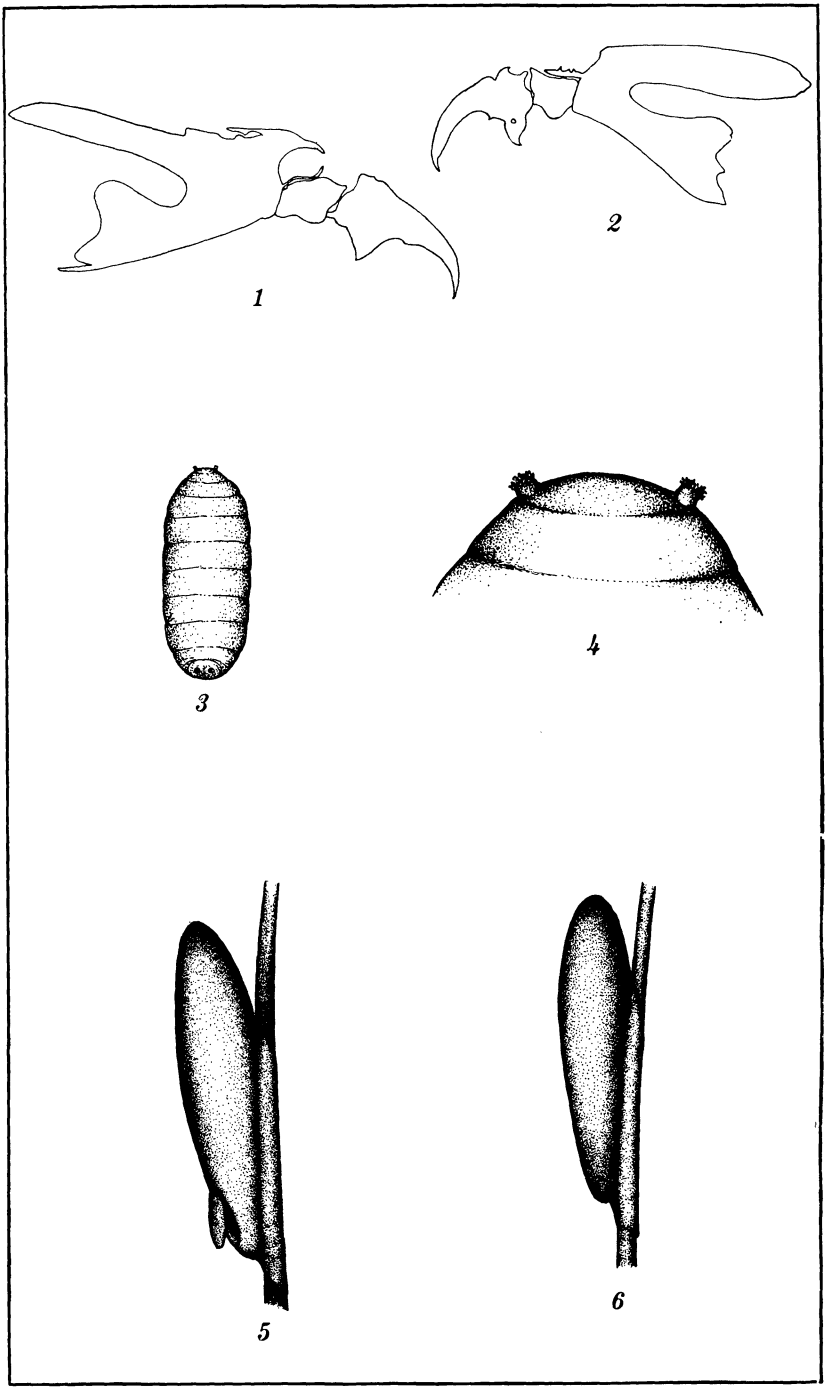

PLATE 2.

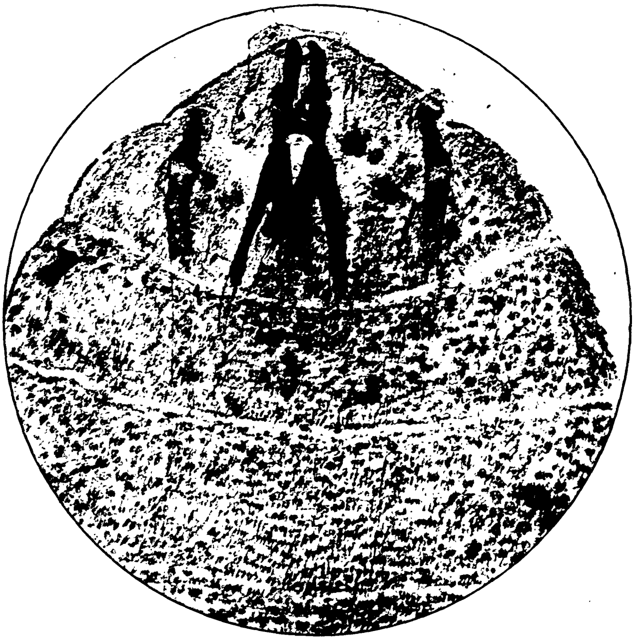

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PLATE 3.

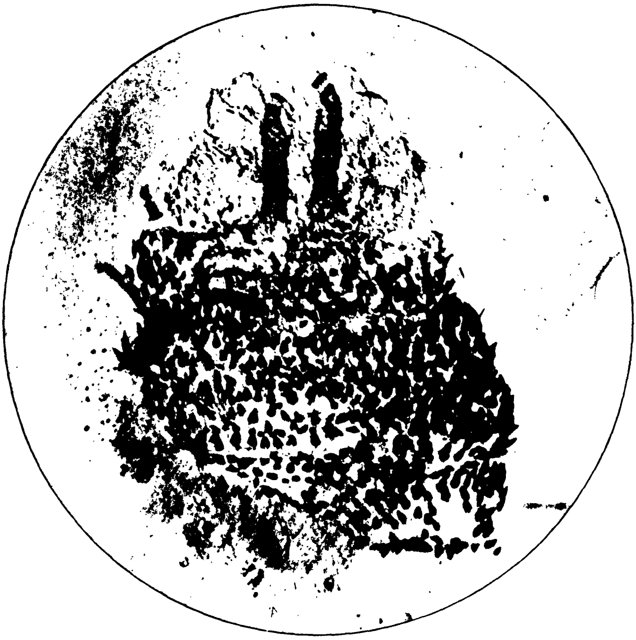

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PLATE 4.

PLATE 5.

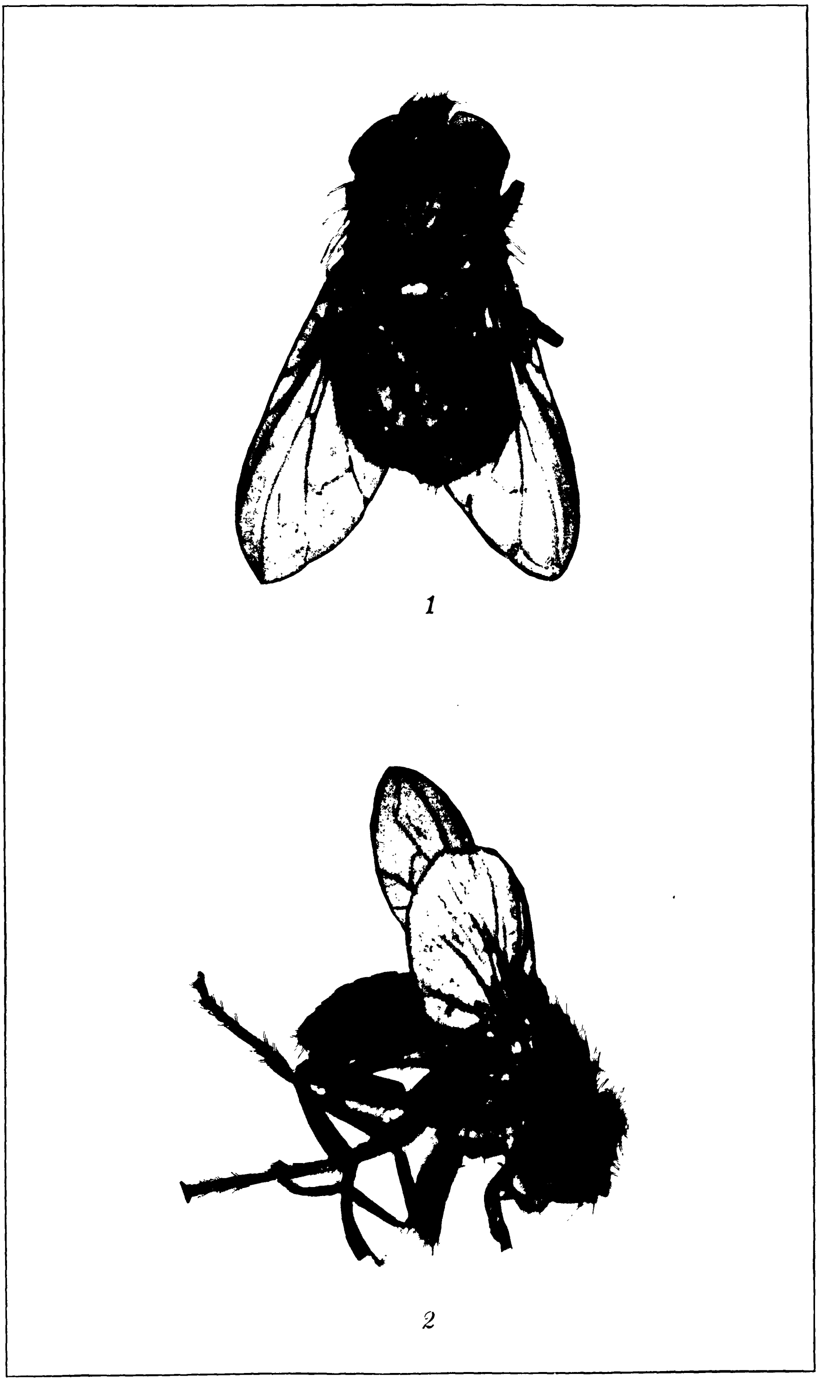

PLATE 6.

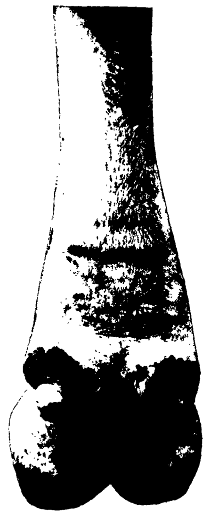

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PLATE 7.

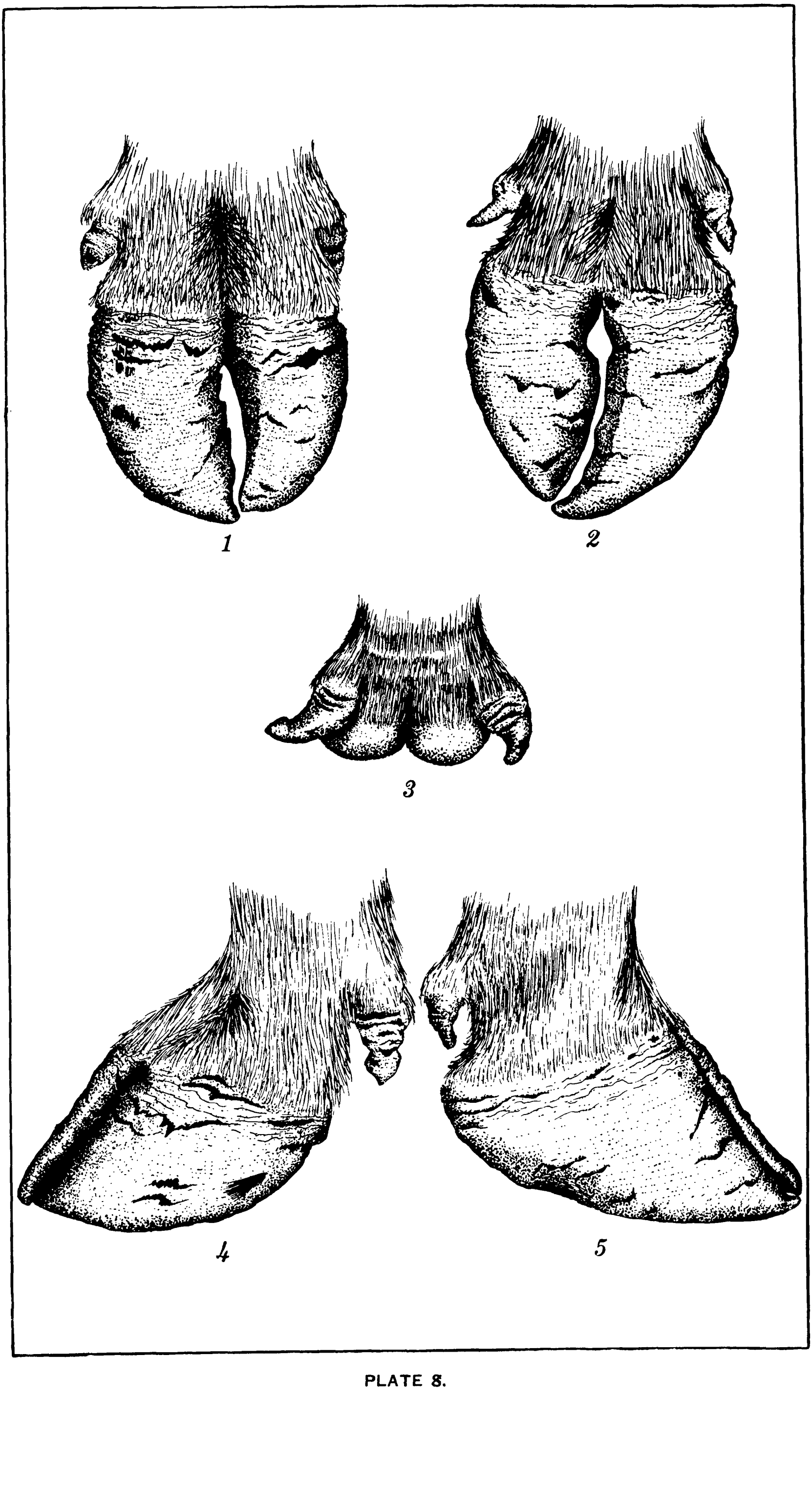

PLATE 8.

A NEW PHILIPPINE STENOCRANUS (DELPHACIDÆ, HOMOPTERA)

By F. Muir

Of the Hawaiian Sugar Planters' Experiment Station, Honolulu

TWO TEXT FIGURES

Stenocranus seminigrifrons sp. nov. Fig. 2.

Male.—Macropterous; length, 2.7 millimeters; tegmen, 3.3. Length of vertex, pronotum, and mesonotum 1.6 times the width of head including eyes; length of vertex 1.5 times the width at base, base slightly broader than apex; length of face 2.2 times the width, sides straight, slightly diverging apically, apex broader than base. Antennæ reaching slightly beyond base of clypeus, first segment longer than broad, second segment 1.6 times the length of first. Lateral pronotal carinæ straight, diverging, not quite reaching hind margin. Hind basitarsus slightly longer than the other two together, spur about as long as basitarsus, thin, with many small teeth on margin.

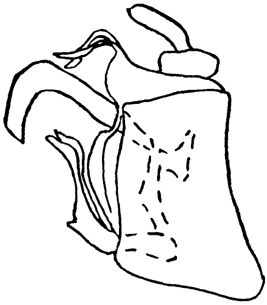

FIG. 1. *Stenocranus nigrifrons* Muir; male genitalia, right lateral view.

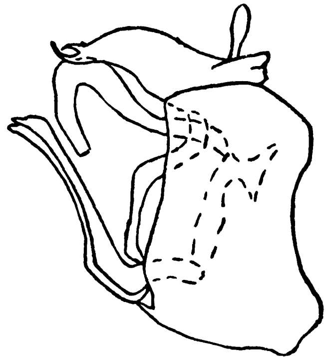

FIG. 2. *Stenocranus seminigrifrons* sp. nov.; male genitalia, right lateral view.

The genitalia of this species differ from those of *S. nigrifrons* Muir in having the anal spines much larger and diverging, with a small spine toward the apex; the ædeagus is curved about one-third from apex into a crook, forming nearly a semicircle, and the genital styles are longer and slender. The two species are closely related.

Ochraceous yellow; fuscous over vertex and base of frons; clypeus dark brown between the lateral carinæ. Tegmina hyaline, slightly ochraceous, slightly fuscous over cubital area.

Female.—Macropterous; length, 3.2 millimeters; tegmen, 3.5. The female I associate with this has the clypeus and the whole of the frons between carinæ dark brown; it also has a lighter mark down dorsum.

Described from one male from Baguio, Benguet Province, Luzon, and one female from Dapitan, Mindanao. There is also a female from Tangkulan, Bukidnon Province, Mindanao (*16785*) and one from Kolambugan, Mindanao (*16784*) which may be of the same species (coll. *Baker*).

This species, as well as *S. nigrifrons,* is not typical of the genus. The first segment of the antennæ is distinctly longer than wide, and the junction of vertex and face in lateral view is parallel with eyes and not produced far enough; but for the present it would better stand in *Stenocranus.*

Nilaparvata bakeri (Muir).

Delphacodes bakeri MUIR, Proc. Haw. Ent. Soc. III 4 (1917) 336, pl. 6, fig. 47.

This species is now known from Formosa.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Stenocranus nigrifrons* Muir; male genitalia, right lateral view.
2. *Stenocranus seminigrifrons* sp. nov.; male genitalia, right lateral view.

THE GENUS MYNDUS IN THE MALAY ISLANDS (HOMOPTERA)

By F. MUIR

Of the Hawaiian Sugar Planters' Experiment Station, Honolulu

ONE PLATE

Genus **MYNDUS** Stål

Myndus STÅL, Berl. Ent. Zeit. 6 (1862) 307; type, *musivus* Stål.

Most of the described species of this genus inhabit North America and the West Indies, thirteen species being recorded from those regions. Two species are recorded from the Palæarctic Region, one from Fiji, and one from Samoa. The present paper describes eleven species from the Malay Islands and thereby gives a totally different orientation to the distribution of this genus. These species differ from the type species in having the vertex and frons comparatively broader, especially *Myndus caligineus*. In this respect they approach such North American species as *M. erotatus* Van Duzee, but in this species the transverse carina is indistinct and there is an indistinct longitudinal median carina on the basal half of the vertex.

The first five are all closely related; *M. semialbus* stands by itself as does *M. dolosus; M. fasciatus* and *M. brunneus* from Amboina are also isolated. The two species from Borneo, *M. mundus* and *M. caligineus,* differ considerably from the others. Many more species of this genus are sure to be found in the Malay Archipelago, but their identification will be almost impossible unless the male genitalia are described or figured.

The types of the new species described in this paper are in the Hawaiian Sugar Planters' Experiment Station collection, Honolulu. Paratypes, when present, are in the Baker collection.

Myndus maculosus sp. nov. Plate 1, fig. 1.

Male.—Length, 2.1 millimeters; tegmen, 2.9. Width of vertex at base slightly greater than length in middle; transverse carina about middle. Length of face subequal to width, narrowest at base. Forking of Sc and R slightly basad of Cu.

Pygofer asymmetrical; right side produced into a large process rounded at apex, left side with a small projection near anal angle; medioventral process subconical in outline. Anal segment asymmetrical, the left margin being much lower than the right. Genital styles small, flat laterally, bent in middle to nearly a right angle, apex bluntly pointed. Periandrium with apical two-thirds membranous, basal third chitinous, a large process on ventral aspect bifurcate at apex, one very small and the other larger and curved, two small spines on the right side; ædeagus membranous.

Stramineous; darker over abdomen. Tegmina hyaline, apices of apical veins fuscous extending a little way down, apical crossveins fuscous, a few small spots at crossveins, one at apex of costa, one at fork of Sc and R, one at fork of Cu, one at apex of clavus, one at fork of clavus; veins stramineous except at spots, tubercles minute, same color as veins. Wings hyaline, veins slightly stramineous.

Female.—Length, 2.2 millimeters; tegmen, 3. In color a little darker than male, especially over the abdomen.

LUZON, Laguna Province, Los Baños (*Muir*), September, 1915, 2 males and 8 females; (*Baker 1304*), 1 female: Tayabas Province, Malinao (*Baker*), 1 female. Type No. 1069.

Myndus mindanaoensis sp. nov. Plate 1, fig. 2.

Male.—Length, 2 millimeters; tegmen, 2.8. In build and coloration this species is very similar to *M. maculosus*, but the genitalia differ as follows:

Right lateral margin of anal segment produced into two pointed processes; the production on right margin of pygofer longer and narrower at base, the angular projection on left side larger; genital styles larger with three small lobes at apex; the basal portion of periandrium having one bilobed process with lobes short, pointed, curved, and of equal length.

Female.—Length, 2.7 millimeters; tegmen, 3. Similar to *M. maculosus*, but slightly darker and the spots on tegmina darker.

MINDANAO, Kolambugan (*Baker*), 1 male: Dapitan (*Baker*), 2 females. Type No. 1070.

Myndus palawanensis sp. nov. Plate 1, fig. 3.

Male.—Length, 2.3 millimeters; tegmen, 2.7. Vertex slightly longer than width at base, base considerably wider than apex; frons slightly longer than wide, narrowest at base. Sc + R forking about middle of costa, Cu forking slightly more distad.

Pygofer asymmetrical, right side produced into a long quadrate process about two and one-half times as long as broad; left side produced into a small angle at anal angle, medioventral process angular. Anal segment large and asymmetrical, the shape as shown in figure. Periandrium with a thick process from near base with its apex bifurcate, a smaller spine nearer the apex. Genital styles flat, narrow, angular in middle.

Light brown. Tegmina hyaline, slightly stramineous, veins slightly darker; tubercles very small, same color as veins; apices of apical veins fuscous, crossveins, a dot at apex of clavus and at apex of costal and at fork of cubitus fuscous. These fuscous spots are very faint in some specimens; and in some there is a faint suggestion of a fuscous mark from middle of costa to apex of clavus.

Female.—Length, 3 millimeters; tegmen, 3.7. Considerably darker in color than the male, marks on tegmina more distinct.

PALAWAN, Puerto Princesa (*Baker 10071*), 3 males and 2 females, type locality. MINDANAO, Dapitan (*Baker 13347, 13348*), 1 male and 2 females; Butuan (*Baker 10073*), 1 female. BASILAN (*Baker*), 3 specimens. BORNEO, Sandakan (*Baker 13343*), 2 males and 2 females. Type No. 1067. There are also three females from Larat (*F. Muir*), December, 1907, and one from Piroe, Ceram (*Muir*), January, 1909, which agree with the Philippine females, but I have not included them in the type material.

Myndus hyalinus sp. nov. Plate 1, fig. 4.

Male.—Length, 2.5 millimeters; tegmen, 3. Width of vertex slightly greater than length in middle, transverse carina about middle, base considerably wider than apex; width of frons nearly equal to length, narrowest at base; median ocellus present. Sc + R forked about middle of costa, Cu forked slightly distad.

Pygofer asymmetrical, the right side produced into a large quadrate process, longer than broad, with the dorsal corner forming a minute point; medioventral margin produced into a conical outlined process. Anal segment large, asymmetrical, as shown in figure. Periandrium with five spines, a large, curved basal one, two smaller slightly distad, and two very small ones near apex. Genital styles bent nearly at a right angle in middle.

Frons, vertex, and mesonotum dark brown; pronotum, legs, and abdomen lighter brown. Tegmina hyaline, slightly stramineous, veins stramineous, tubercles very small, same color as veins. Wings hyaline with light brown veins.

Female.—Length, 3 millimeters; tegmen, 3.3. Same color as male. Ovipositor considerably longer than pygofer, projecting well beyond apex of anal segment; pygofer longer than wide.

MINDANAO, Butuan (*Baker 10074*), 2 males and 2 females: Iligan (*Baker 10072*), 1 female. Type No. 1066.

Myndus obscuratus sp. nov. Plate 1, fig. 5.

Male.—Length, 3 millimeters; tegmen, 3.8. Length of vertex in middle equal to width at base; transverse carina about middle; face about as wide as long. Forking of Sc and R about middle of costa, Cu forking slightly more distad.

Pygofer asymmetrical, the right side being produced into a large process, medioventral process angular. Anal segment asymmetrical, in lateral view the left side of the ventral margin produced into a large angular process slightly curved, the dorsal margin into a large angular process, the apex pointed, the right side not so produced. The genital styles curved, with a large rounded process in the middle of the inner margin, apex slightly rounded. Periandrium fairly large with seven or eight spines as in figure.

Stramineous; slightly darker over vertex and middle of mesonotum. Tegmina hyaline, very slightly stramineous; veins stramineous, slightly fuscous on apices; tubercles numerous, minute; a faint fuscous mark at apex of clavus. Wings hyaline, veins light brown.

Female.—Length, 3.4 millimeters; tegmen, 4. Similar to male but darker over thorax and abdomen; ovipositor projecting beyond the pygofer, pygofer longer than wide.

LUZON, Mount Banahao (type locality) and Mount Maquiling (*Muir*), February, 1914; (*Baker 2824, 2883, 10071*), 5 males and 3 females. Type No. 1068.

Myndus semialbus sp. nov. Plate 1, fig. 6.

Male.—Length, 2 millimeters; tegmen, 2.5. Length of vertex in middle very slightly less than width at base, apex slightly narrower than base; transverse carina in middle, distinct. Length of face equal to width, narrowest at base, widest before apex, frontal ocellus distinct. Forking of Sc and R about one-third from base, M leaving Sc + R near base, Cu forking slightly before apex of clavus, M with five apical veins.

Pygofer symmetrical, medioventral margin produced into a process subconical in outline, lateral angles produced into a rounded process which is produced into a spine on the lower portion. Anal segment large, asymmetrical, the ventral margin

produced and ending in two unequal spines. Genital styles small, flat, curved, apex truncate. Periandrium short, the basal portion produced into a large spine and the apical margin into a small spine, penis membranous.

Dark brown; legs, pygofer, and anal segment lighter. Tegmina hyaline, basal portion to nodal line brown with a light band through the middle, apical half hyaline with a waxy covering making it white. Veins same color as membrane, tubercles small, numerous, bearing light macrotrichia. Wings hyaline with brown veins.

Female.—Length, 2.2 millimeters; tegmen, 2.7. Color similar to that of male. Pygofer longer than wide, ovipositor complete, a little longer than pygofer.

LUZON, Mount Banahao and Mount Maquiling (*Muir*), September, 1915; (*Baker*), 4 males and 3 females. Type No. 1064.

Myndus dolosus sp. nov. Plate 1, fig. 7.

Male.—Length, 2.6 millimeters; tegmen, 3. In general build and markings this species is similar to *M. maculosus*, but the genitalia differ. In lateral view the anal segment beyond anus is not produced into an angle but is rounded, the apex is rounded asymmetrically; the right margin of pygofer is angularly produced; the left margin slightly sinuous but not produced; genital styles not so angularly bent in middle; the ædeagus is small, the apical portion of the periandrium and the penis are membranous, the basal portion of periandrium is produced into two similar, flat, curved spines with a couple of minute spines between them on ventral aspect.

Straits Settlements, Penang Island (*Baker 10077*), 3 males. Type No. 1071.

Myndus fasciatus sp. nov. Plate 1, fig. 8.

Male.—Length, 2 millimeters; tegmen, 2.7. Length of vertex in middle equal to width at base, base shallowly emarginate, transverse carina about middle, obscure; face slightly longer than broad, median ocellus distinct. Cu forking slightly before apex of clavus, Sc + R before Cu, about one-third from base, M joining Sc + R near base, M with five apical veins.

Pygofer and anal segment asymmetrical; periandrium fairly long with three spines near apex. Genital styles flat, fairly narrow, angular, apex truncate with a minute spine on outer angle. The shape of genitalia is better shown in figures.

Light brown, mesothorax darker with lighter carinæ, legs light. Tegmina hyaline, a brown mark down middle of clavus,

broad at base and narrowing to apex, a brown band across from middle of costa to apex of clavus with two darker marks on costa, apex brown, two brown marks on costa before stigma, veins same color as membrane except in hyaline band across corium where there are some brown marks on the veins; tubercles minute, same color as veins.

Female.—Length, 2.6 millimeters; tegmen, 2.8. Body slightly darker in color. Ovipositor slightly longer than pygofer.

AMBOINA, March and April, 1908 (*Muir*), 1 male and 4 females. Type No. 1065.

Myndus brunneus sp. nov. Plate 1, fig. 9.

Male.—Length, 2.6 millimeters; tegmen, 2.9. Length of vertex along middle equal to width of base, base wider than apex, transverse carina in middle distinct, base roundly emarginate. Length of face equal to width, narrowest at base, gradually widening to near apex, then narrowing, sides rounded on apical half. Frontal ocellus distinct. Forking of Sc_2 and R_9 near middle; M leaving Sc and R at base; C forking about level with the fork of Sc and R; M with five apical veins, namely, 1, 1a, 2, 3, and 4; R with two apical veins. Claval veins joining commissure before apex of clavus.

Pygofer symmetrical, lateral margins entire; medioventral edge produced into a small angular process. Anal segment median size, asymmetrical, on the right side a spine arises from the margin and is directed basally, on the left side a longer spine is directed ventrally at right angle to anal segment. Ædeagus median size, the epiandrium flattened laterally with three large spines on the ventral aspect near apex, the two apical spines thin and curved, the more basal one broad at base and serrated on edge and drawn out into a fine point. Genital styles flattened laterally, angular about middle, apex broad and truncate, a flange or carina runs from near apex to ventral margin near base.

Brown; rostrum, legs, and hind margin of pronotum lighter. Tegmina brown, lighter in middle, veins slightly darker, tubercles small, bearing black macrotrichia. Wings fuscous, veins brown.

Female.—Length, 2.9 millimeters; tegmen, 3.4. In build and color similar to male. Ovipositor projecting beyond pygofer; anal segment a little longer than broad.

AMBOINA, January, 1908 (*Muir*), 1 male (holotype), 1 female (allotype), 1 damaged male. Type No. 1048.

Myndus mundus sp. nov. Plate 1, fig. 10.

Male.—Length, 2.7 millimeters; tegmen, 3. In build and color this species is very much like *M. hyalinus,* but it is slightly lighter in color and the genitalia are quite distinct.

Pygofer symmetrical, the medioventral process short and widely angular. Anal segment but slightly asymmetrical, apex rounded, left margin slightly lower than right. Periandrium fairly large, subangularly produced on dorsal aspect near apex, with two long, thin processes arising from a common base and forming a U-shaped process near the apical margin on right side, penis considerably chitinized with two long spines and a small one between them. Genital style nearly straight, slightly curved at apex where it is produced into a broad spine pointing basad. Apex round, inner margin entire, slightly convex at apex, outer margin slightly sinuous.

Female.—Length, 3 millimeters; tegmen, 3.7. Similar to the male; lighter in color than *M. hyalinus.*

BORNEO, Sandakan (*Baker*), 1 male and 1 female. Type No. 1072.

Myndus caligineus sp. nov. Plate 1, fig. 11.

Male.—Length, 2.4 millimeters; tegmen, 3. Width of vertex at base considerably (one-third) greater than length in middle; transverse carina distinct in middle; frons about as wide as long, slightly larger before apex, base and apex subequal in width; median ocellus distinct. Fork of Sc and R near base, fork of Cu about middle of clavus.

Pygofer symmetrical, medioventral process small, lateral margins entire, not produced. Anal segment symmetrical, much longer than broad, apex rounded, anus about middle. Periandrium long, tubular, with one large spine on ventral aspect near apex pointing basad; penis long, semichitinous with four spines, two about middle, the other two more apical. Genital style small, inner margin entire, slightly convex, outer margin straight on basal half, then concave, apex truncate.

Dark castaneous, legs slightly lighter. Tegmina dark castaneous, tubercles small, numerous, dark; wings castaneous, veins darker.

Female.—Length, 2.8 millimeters; tegmen, 3.3. In coloration similar to male.

WEST BORNEO, Mowong, September, 1907 (*Muir*), 1 male and 1 female. Type No. 1073.

ILLUSTRATION

PLATE 1

FIG. 1. *Myndus maculosus* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

2. *Myndus mindanaoensis* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

3. *Myndus palawanensis* sp. nov.; *a*, genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

4. *Myndus hyalinus* sp. nov.; *a*, pygofer and anal segment, right lateral view; *b*, ædeagus and left style, left lateral view; *c*, anal segment, end view.

5. *Myndus obscuratus* sp. nov.; *a*, male genitalia with ædeagus dissected out, lateral view; *b*, ædeagus, left lateral view.

6. *Myndus semialbus* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

7. *Myndus dolosus* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

8. *Myndus fasciatus* sp. nov.; *a*, male pygofer and anal segment, left lateral view; *b*, ædeagus and right genital style, right lateral view.

9. *Myndus brunneus* sp. nov.; ædeagus and right genital style, right lateral view.

10. *Myndus mundus* sp. nov.; ædeagus and right genital style, right lateral view.

11. *Myndus caligineus* sp. nov.; *a*, ædeagus, left lateral view; *b*, left genital style, lateral view.

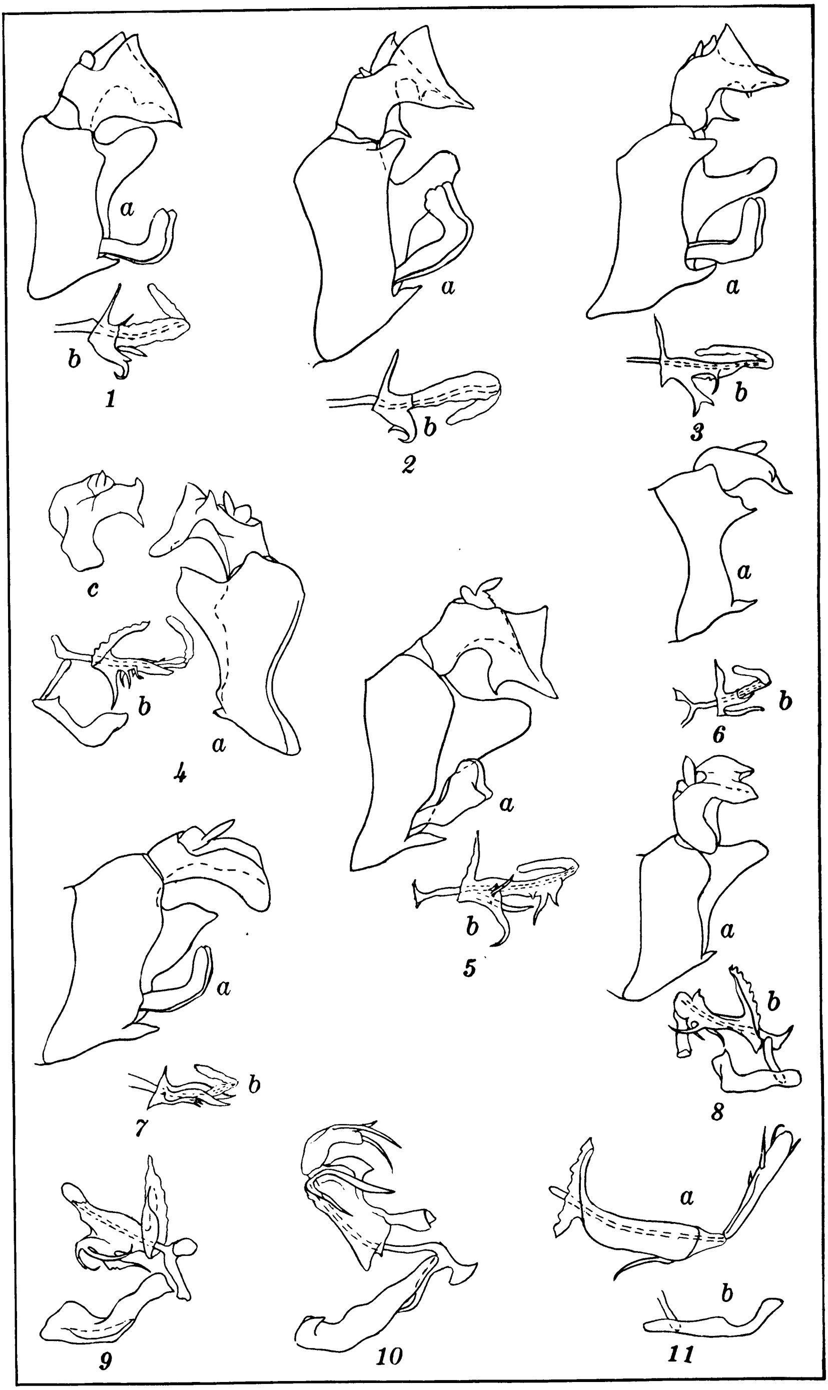

PLATE 1. GENITALIA OF SPECIES OF MYNDUS.

TWO COLLECTIONS OF FULGOROIDEA FROM SUMATRA

By F. Muir

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ONE PLATE

Very little is known about the fulgorids of Sumatra, especially the small species, so the two small collections, one made by Mr. E. Jacobson and the other by Mr. J. B. Corporaal, are of interest. Besides the species mentioned, there are eight species of Cixiidæ which I am retaining for the present. The types are deposited in the Hawaiian Sugar Planters' Experiment Station collection in Honolulu.

ACHILIDÆ

Rhotala depressifrons sp. nov.

This species is similar in structure to *R. gravelyi* Muir from India, with the following exceptions. The vertex is narrower and longer, the base angularly emarginate with a fine carina, sides with carina rounded off at apex. Base of face smooth and shining, the lateral carinæ at base thickened, becoming slenderer to apex, having a triangular depression over the greater part of the face, a slight trace of a median carina on apical third. There is no trace of a suture dividing the posterior angle of the mesonotum and so it cannot be placed in the Tropiduchidæ, and the whole build and characters of the insect are achilid.

Female.—Length, 10 millimeters; tegmen, 11. Dark brown, with small lighter brown marks; legs with slightly lighter bands. Tegmina brown, with slightly dark brown mottlings, veins darker; wings light brown, with darker veins.

Pregenital plate large, short at sides, hind margin gradually produced to middle third which is steeply produced into a long, narrow process slightly bilobed at apex, with the sides curved dorsad, this middle process being as long as basal portion of pregenital plate; genital styles long, narrow, the anterior styles lying in the groove formed by the produced pregenital plate, the posterior pair straight, narrow, apex rounded, reaching nearly to apex of median process of pregenital plate. Anal segment small, longer than broad, rounded at apex.

SUMATRA, Bandar Baroe, November 26, 1919 (*J. B. Corporaal*), 1 female. Type No. 1059.

The venation of this genus is very distinct, the cubitus having six to eight apical veins.

CIXIIDÆ

Kinnara nigrocacuminis sp. nov. Plate 1, fig. 1.

In this genus vein R, after leaving Sc, joins M for a short distance.

Male.—Length, 2.6 millimeters; tegmen, 4.3. Stramineous; front tibiæ fuscous, abdomen dark brown, light on pleura. Tegmina hyaline, shiny, the apex from apex of Sc to apex of Cu1a dark fuscous; veins same color as membrane; wings hyaline, fuscous, veins dark brown.

Lateral processes of pygofer narrow, long, apex acute, curved, and slightly recurved. Anal segment large, length about three times the width, sides subparallel, anus near apex beyond which apex is narrowed to a point. Genital styles flat, narrow, curved, gradually narrowed to apex. Ædeagus complex with membranous filament at apex which appears to be common to this genus.

SUMATRA, Bandar Baroe, January 14, 1920 (*Corporaal*). Type No. 1060.

Borysthenes diversa (Distant).

SUMATRA, Bosehr Banda, January, 1920 (*Corporaal*), 1 female.

I identify this specimen as of this Indian species, but the male may show it to be different. The specimen is in bad condition but it agrees quite well with Distant's figure and description.

Kermesia maculata Melichar.

SUMATRA, Fort de Kock, June, 1921 (*E. Jacobson*), 1 male.

Eight other species of Cixiidæ await further study in connection with a large collection of this family from the Philippines.

DELPHACIDÆ

Ugyops notivena (Walker).

SUMATRA, Tandiong Merah, 1919 (*Corporaal*), 2 females.

Until the type of this species is redescribed and the male genitalia are examined there must be some uncertainty as to identification.

Melanesia sp.

SUMATRA, Paga Maban, December, 1919 (*Corporaal*), 1 female. This appears to be an undescribed species, but the male is necessary for certainty.

Perkinsiella neoinsignis sp. nov. Plate 1, fig. 2.

In all external characters this species agrees with the Indian *P. insignis* (Distant), but the genitalia are quite distinct.

Opening of pygofer longer than wide, anal emargination large, anal angles not produced, medioventral margin produced into a small horizontally flat process deeply emarginate in middle, thus forming two flat processes; diaphragm long, dorsal margin V-shaped in middle. Anal segment large with two long, thin spines with their bases far apart. Genital styles not reaching to anal segment, apex truncate, narrow, inner margin straight on apical half, slightly concave on basal, outer margin concave on apical half, produced slightly on basal. Ædeagus large, flattened laterally, in lateral view curved, orifice on dorsal aspect of apex; basad of orifice there are two spinelike processes; one long, flat process curved to right, the other a small process slightly curved to left.

SUMATRA, Medan, 1920 (*Corporaal*), 1 male. Type No. 1061.

In *P. insignis* the medioventral process of pygofer is much broader and the two processes diverge slightly; the genital styles are much narrower at apex and gradually wider to basal angle; the ædeagus has two small spines about equal in size.

Dicranotropis corporaali sp. nov. Plate 1, fig. 3.

Male.—Length, 2 millimeters; tegmen, 2.4. The lateral carinæ of pronotum diverging posteriorly but not curved; median carinæ of face forked about one-third from base. Stramineous; mesonotum slightly sordid. Tegmina hyaline, slightly stramineous, veins same color as membrane, tubercles small, sparse, same color as veins bearing stramineous macrotrichia. Genitalia figured. The genital styles are very distinctive.

SUMATRA, Medan, 1920 (*Corporaal*), 1 male. Type No. 1062.

Phyllodinus platypoda (Dammerman).

SUMATRA, Fort de Kock, 920 meters elevation, November, 1920 (*Jacobson*), 1 female.

This species was originally placed in *Platybrachys* Dammerman, but that name is preoccupied. *Phyllodinus* Van Duzee as it stands at present consists of two genera and, until it is

straightened out, it is useless to give a new name to *Platybrachys* Dammerman.

Sogata furcifera (Horvath).

SUMATRA, Fort de Kock, 920 meters elevation, January, 1921 (*Jacobson*), 5 specimens.

This species has nearly a world-wide distribution. I have not yet placed it in any genus with any satisfaction but believe it is best placed in *Sogata.*

Nilaparvata greeni Distant.

SUMATRA, Fort de Kock, 920 meters elevation, January, 1921 (*Jacobson*), 3 males and 2 females.

The type of this genus, *N. greeni* Distant, is the same as *Dicranotropis anderida* Kirkaldy, and the same as what Melichar identifies as *Delphax sordescens* Motschulsky. I am deeply indebted to Doctor Bergroth for critical remarks and copies of the original descriptions of some of Motschulsky's species of *Delphax.* He suggests that possibly Melichar's identification of *D. sordescens* may not be correct. In this I quite agree with him and shall consider *greeni* as the type until the type of *D. sordescens* has been reëxamined.

This species has a wide distribution from Australia to India, China, and Formosa. The distinctive feature of the genus is two or three small spines on the hind basal tarsal segment.

Delphacodes striatella (Fall).

SUMATRA, Fort de Kock, February, 1921 (*Jacobson*), 1 male.

It is interesting to find this European species in Sumatra.

DERBIDÆ

Herpis borneensis Muir. Plate 1, fig. 4.

SUMATRA, Medan, October 20, 1920 (*Corporaal*), 1 male: Fort de Kock, November, 1920 (*Jacobson*), 1 female.

The genital styles are slightly more angular than in the type specimen. The ædeagus has not been dissected out.

Vekunta punctula (Melichar).

SUMATRA, Medan, January 31, 1921 (*Corporaal*), 1 female.

This specimen agrees with the description, but as no mention is made of the genitalia or even the sex, of the type, the identification remains uncertain.

Pregenital plate large, short at sides, the outer thirds of the hind margin nearly straight, the middle third produced into a

large process longer than broad, gradually widening from base to middle, then gradually narrowing to the rounded apex. Anal segment slightly longer than wide, apex broadly rounded. Genital styles fairly large, projecting beyond apex of pregenital plate.

Vekunta pseudobadia Muir.

SUMATRA, Medan, December 30, 1920 (*Corporaal*), 1 female.

Kaha perplexa (Muir).

SUMATRA, Medan, February, March, 1920 (*Corporaal*), 1 male and 3 females.

Proutista moesta (Westwood).

SUMATRA, Haboko, July 23, 1920 (*Corporaal*), 2 males: Mopoli Atjeh, September 15, 1920 (*Corporaal*), 1 female.

Zoraida cumulata (Walker).

SUMATRA, Atjib aloer Djombae, September 15, 1920 (*Corporaal*), 2 females.

The specimens are much damaged, but the genitalia enable me to identify this widely distributed species.

Zeugma corporaali sp. nov. Plate 1, fig. 5.

In size, general build, and color this species is similar to *Z. monticola* Kirkaldy (=*Z. vittata* Westwood?), but the genitalia are quite distinct. In *Z. corporaali* sp. nov. the ædeagus is longer and the apical, bifurcate portion has one large spine in the middle on the side and a broad, bifurcate or subcrescent-shaped process at apex; it also has a series of trifurcate spines. In *Z. monticola* Kirkaldy (Plate 1, fig. 6) the ædeagus is shorter and the apical portion has two small spines in the middle and a bidentate process at apex, and it has no trifurcate spines. The lateral margins of the pygofer are also distinct. The female of *Z. corporaali* differs from *Z. monticola* in having the basal margin of the pregenital plate raised into a rim instead of a small, raised rim forming a small arc slightly posterior to basal margin.

SUMATRA, Medan, December 5, 1918 (*Corporaal*), 1 male, and October 9, 1918 (*Corporaal*), 1 female. Type No. 1063.

This genus is now known from Formosa, the Philippines, Borneo, Java, Sumatra, Malay Peninsula, and India.

ILLUSTRATION

PLATE 1

FIG. 1. *Kinnara nigrocacuminis* sp. nov.; pygofer and anal segment of male, lateral view.

2. *Perkinsiella neoinsignis* sp. nov.; *a*, apex of ædeagus, dorsal view; *b*, right genital style.
3. *Dicranotropis corporaali* sp. nov.; *a*, genitalia of male, three-fourths view; *b*, anal segment and ædeagus, lateral view.
4. *Herpis borneensis* Muir; male genitalia, lateral view.
5. *Zeugma corporaali* sp. nov.; *a*, ædeagus; *b*, pygofer, lateral margin.
6. *Zeugma monticola* Kirkaldy; *a*, ædeagus; *b*, pygofer, lateral margin.

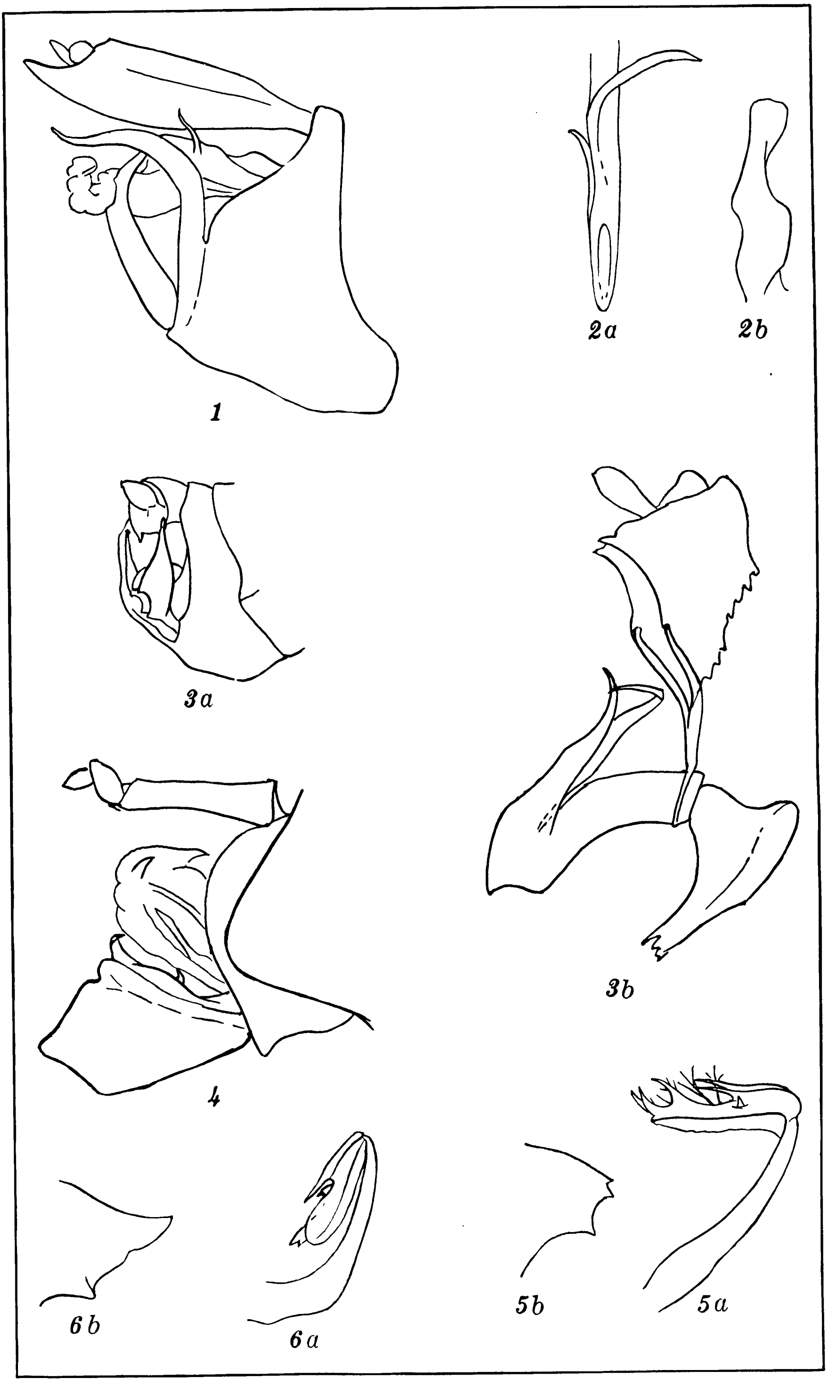

PLATE 1.

LYCOPODIACEAE BORNEENSES

Auct. W. Herter

Berlin, Germany

Im Jahre 1921 sandte mir Herr Merrill, Director, Bureau of Science, Manila, P. I., vereint mit philippinischen Lycopodiaceen, deren Bearbeitung an anderer Stelle veröffentlicht wird,[1] auch eine kleine, sehr schöne Sammlung von Borneo-Lycopodiaceen. Die Pflanzen stammen zwar alle aus derselben Gegend der Insel Borneo, nämlich aus dem zwischen dem 2. und 7. Grad nördl. Breite gelegenen englischen Norden der Insel (British North Borneo und Sarawak), doch gibt die Sammlung einen guten Einblick in die Lycopodiaceenflora der grossen Insel, von der bisher nur spärliches Material in die Herbarien Europas gelangt ist, sodass es sich lohnt, dieselbe einer näheren Betrachtung zu unterziehen. Das Material enthält 15 Species, 12 *Urostachys-* und 3 *Lycopodium*-Arten. Davon ist besonders *U. selago* interessant, eine boreale Species, die zwar schon oft aus tropischen Gegenden angegeben, bisher aber noch nie mit Sicherheit nachgewiesen worden ist. Es hat sich vielmehr fast stets herausgestellt, dass es sich ebenso wie bei den extraeuropäischen Funden innerhalb des borealen Florenreichs (*U. lucidulus* und *porophilus* in Nordamerika, *U. sinensis, tenuifolius,* und *Delavayi* in Ostasien) auch bei den extraborealen Funden (*U. Hildebrandtii* auf Madagaskar, *U. saururoides* auf Ascension, *U. barbatus* in Costarica, *U. haleakalae* auf Hawaii, *U. miniatus* auf Java, *U. Christii* in Brasilien, u.s.w.) um eigene gute Arten aus der Gruppe *Selagina* handelt. Hier liegt indessen unzweifelhaft echter *U. selago* vor, anscheinend ein uralter Bewohner uralter Gebiete. Neu ist *U. borneensis,* Gruppe *Euphlegmaria,* wohl eine endemische Art. Die übrigen Arten sind dieselben, die auch auf den benachbarten grossen Sundainseln sowie auf den Philippinen und zum Teil auch auf Neu Guinea vorkommen, wie die Uebersicht auf Seite 183 erkennen lässt. Von den Philippinen wurden bisher 22 (15 *Urostachys* + 7 *Lycopodium*) Arten, von Neu Guinea 18 (14 + 4) Arten bekannt; erstere beherbergen 6 (5 + 1), letzteres beherbergt 8 (8 + 0) Endemismen.

[1] Philip. Journ. Sci. 22 (1923) 57–76.

Genus **UROSTACHYS** (Pritz.) Herter

UROSTACHYS SELAGO (L.) Hert. comb. nov.

Lycopodium selago Linn. Sp. Pl. (1753) 1102.

Optime congruit cum speciebus europaeis. Plantae robustae bulbillis praeditae.

British North Borneo, Mount Kinabalu fl. Jul., Aug., 1916, *Haslam s. n.;* Paka Cave to Low's Peak, fl. Nov., 1015, *Topping 1688,* elev. 4,000 m., fl. Nov., 1913, *Clemens 10613;* Paka Cave to Lobang, fl. Nov., 1915, *Clemens 10714.*

UROSTACHYS SERRATUS (Thunb.) Hert. in Philip. Journ. Sci. 22 (1923) 61.

British North Borneo, Mount Kinabalu, Kiau, fl. Oct.–Nov., 1915, *Topping n. 1564;* along trail on ground, fl. Nov., 1915, *Clemens 10235;* Marai Parai Spur, ridge trail, fl. Dec., 1915, *Clemens 11052;* Gurulau Spur. fl. Nov., 1915, *Topping 1628.*

UROSTACHYS SQUARROSUS (Forst.) Hert. in Philip. Journ. Sci. 22 (1923) 62.

British North Borneo, Mount Kinabalu, Kiau, fl. Nov., 1915, *Topping 1635, Clemens 9957, 9987;* Kiau to Lobang, fl. Nov., 1915, *Topping 1582;* Keung, river bank, fl. Dec., 1915, *Clemens 9890.*

UROSTACHYS WHITFORDI Hert. in Philip. Journ. Sci. 22 (1923) 63.

British North Borneo, Labang, Soeda, fl. Oct., 1912, N. Borneo Boundary Commission, *Capt. V. Ganderen (coll. Amdjah) 274:* Sarawak, *Native collector 59, 1516.*

An potius species propria affinis *U. squarroso* (Forst.) Hert. diversa a speciebus philippinensibus *U. Whitfordi* Hert. et *U. Magnusianus* Hert. ? Confer species novoguineenses U. Hellwigi (Warb.) Hert. nov. comb. et U. Lauterbachi (Pritz.) Hert. nov. comb. [*Lycopodium Hellwigi* Warb. Monsunia 1 (1898), *Lycopodium Lauterbachi* Pritz.]

UROSTACHYS CARINATUS (Desv.) Hert. in Philip. Journ. Sci. 22 (1923) 64.

Borneo, ster., Korthals ex Herb. Lugd. Bat.: Sarawak, ster., *Native collector 60, 967;* Lundu, Santubong, fl. May, 1908, *Foxworthy 116, 330.*

UROSTACHYS PINIFOLIUS (Blume) Hert. in Philip. Journ. Sci. 22 (1923) 65.

Sarawak, *Native collector 73.*

Planta juvenilis s. forma specialis, similis Mindanao, Lake Lanao, Camp Keithley, fl. Jul. 1907, *Clemens s. n.*

UROSTACHYS ELMERI Hert. in Philip. Journ. Sci. 22 (1923) 65.

British North Borneo, Kalabakan, in forests on *Canarium* tree, alt. 150 m, fl. Sept., 1916, *Villamil 210.*

An species distincta, affinis U. phyllantho (Hook. & Arn.) Hert. comb. nov. *Lycopodium phyllanthum* Hook. & Arn. Bot. Beechey Voy. (1841) 103.

UROSTACHYS BANAYANICUS Hert. in Philip. Journ. Sci. 22 (1923) 66.

British North Borneo, Mount Kinabalu, Kiau, fl. Nov., 1915, *Clemens 10242.*

UROSTACHYS PLEGMARIA (L.) Hert. in Philip. Journ. Sci. 22 (1923) 66.

British North Borneo, Mount Kinabalu, fl. Jul.–Aug., 1916, *Haslam s. n.;* Keung to Kibayo, fl. Nov., 1915, *Topping 1909;* Kiau, fl. Nov., 1915, *Clemens 10107;* Mount Tuaran, forest trail, fl. Dec., 1915, *Clemens 11271:* Sarawak, *Native collector 54, 57, 773, 964, 966;* Baram District, fl. Nov., 1894, *Charles Hose 723;* Mount Sudan, fl. Feb.–Jun., 1914, *Native collector 2087;* east of Bukit Trumat, near Pentop, *Native collector 1515* pp. cum *U. borneensi.*

UROSTACHYS BORNEENSIS Hert. sp. nov.

Radix fasciculata. Frons luteo-viridis, quater bipartita, pendula, flaccida, long. 10–20 cm, lat. 8–12 mm. foliis inclusis. Caulis flaccidus, basi 1 mm lat. foliis exclusis. Flores flaccidi, bipartiti, long. 4–5 cm, lat 1.2 mm. Folia sparsa, ± sexfaria, 6–15 pro cm, axim non tegentia, horizontaliter patentia, ovato-lanceolata, acuminata, nitida, plana, non carinata, abruptim in sporophylla transeuntia, 1–3 x 4–6 mm. Sporophylla densa, ovato-lanceolata, erecto-appressa, sporangia subtegentia, 0.5 x 1 mm. Sporangia vix 1 mm lata.

Sarawak, *Native collector 1515 p. p., 1540,* cum *U. phlegmaria* Hert.

Species distinctissima affinis *U. Ledermanni Hert.* et *U. flagellaceo* (Kuhn) Hert.

UROSTACHYS SALVINIOIDES Hert. in Philip. Journ. Sci. 22 (1923) 67.

A typo philippinensi satis diversa, an species propria?

British North Borneo, Mount Kinabalu, fl. Jul.–Aug., 1916, *Haslam s. n.;* Gurulau Spur, summit, fl. Nov., 1915, *Clemens 10778;* Mount Bungal, fl. Dec., 1915, *Clemens 11216.*

UROSTACHYS NUMMULARIIFOLIUS (Blume) comb. nov.

Lycopodium nummularifolium Blume Enum. Pl. Jav. (1828) 263.

Sarawak, *Native collector 58, 774, 1547, 1548;* Amproh River, fl. Feb.–Jun., 1914, *Native collector 2143:* British North Borneo, Mount Kalawat, on ant's nest, fl. Dec., 1915, *Clemens 11144.*

Genus LYCOPODIUM (L.) Herter

LYCOPODIUM SCARIOSUM Forst. Prodr. Florul. Ins. Austral. (1786) 87.

British North Borneo, Mount Kinabalu, Paka Cave, fl. Nov., 1915, *Topping 1674, 1700;* Paka Cave to Low's Leak, fl. Nov., 1915, *Topping* fl. Nov., 1915, *Clemens 10651;* Paka Cave to Lobang, erect *Lycopodium* under shrubbery, fl. Nov., 1915, *Clemens 10730,* fl. Jul.–Aug., 1916, *Haslam s. n.*

LYCOPODIUM CERNUUM L. Sp. Pl. (1753) 1103.

Var. **CAPILLACEUM** Spring Monogr. Lycop. 1 (1842) 80. [*L. bryifolium* Ventenat mscr.—*? L. marianum* Desv. mscr.—*L. cernuum β laxum* Blume En. Pl. Jav. 2 (1828) 266.]

Forma **TYPICA** Hert. f. nov.

Differt floribus brevibus (3 x 6–8 mm), fronde 6–8 mm lata.

British North Borneo, Sandakan, in shallow moist cave at base of sandstone cliff, fl. Oct., 1908, *Foxworthy 576*; fl. Oct., 1915, *Topping 1366.*

Forma **LONGIFLORA** Hert. f. nov.

Differt floribus longibus (2 x 16–18 mm), fronde 3–4 mm lata. Planta distinctissima.

British North Borneo, Sandakan, fl. Oct., 1908, *Foxworthy 582.*

Var. **VULCANICUM** Hert. var. nov. [*? L. curvatum* Sw. Syn. Fil. (1806) 178 & 402; *? L. cernuum β curvatum* Hook. & Grev. En. Fil. (1831) n. 34;—*? L. convolutum* Desv. ex. Lam. Enc. Bot. Suppl. 3 (1813) 546—*L. curvatum & vulcanicum* Blume En. Pl. Jav. 2 (1828) 266—*L. cernuum δ crassifolium & L. curvatum* Spring Monogr. Lycop. 1 (1842) 80 & 81—*? L. marianum* Willd. mscr.—*L. cernuum* forma *vulcanica* Hert in Engl. Bot. Jahrb. 54 (1916) 235.]

Differt fronde rigidissima.

Hic forma *ramosissima* Hert. in Engl. Bot. Jahrb. 54 (1916) 235.

Labuan, fl. Nov., 1902, *Merrill n. n.:* British North Borneo, Kiau, fl. Nov., 1915, *Clemens 10228;* Gurulau Spur, fl. & ster. Nov., 1915, *Clemens 10806, 10852, 10881;* Sandakan, ster. Oct., 1915, *Topping 1357,* Marai Parai Spur, ster., Nov., 1915, *Topping 1875;* Paka Cave, ster., Nov., 1915, *Topping 1673;* Jesselton,

fl. Oct., 1915, *Topping 1461;* on hillside 25–50 m alt., fl. Oct., 1917, *Yates 67;* brushland, 120 m alt., fl. Feb., 1916, *Villamil 139.* Sarawak, *Native collector 766, 1863, 1973;* summit of Mount Murud, fl. Dec., 1914, *Native collector 2857, 2858.*

LYCOPODIUM CASUARINOIDES Spring Monogr. Lycop. 1 (1842) 94.

British North Borneo, Mount Kinabalu, Paka Cave to Lobang, ster. Nov., 1915, *Topping 1754;* Kemberanga, covering shrubbery, ster., Nov., 1915, *Clemens 10520,* ster., Jul.–Aug., 1916, *Haslam s. n.*

ÜBERSICHT ÜBER DIE LYCOPODIACEEN VON BORNEO, VON DEN PHILIPPINEN, UND VON NEU GUINEA

Die Endemismen sind fett, die sonstigen, nur in einem der drei Gebiete gefundenen Arten sind cursiv gedruckt.

Genus Urostachys.

	Sectio.						
	Selaginurus.	*Tenuifoliurus.*	*Linifoliurus.*	*Squarrosurus.*	*Carinaturus.*	*Phlegmariurus.*	*Nummulariifoliurus.*
Borneo	**selago.** *serratus.*			*squarrosus.* *Whitfordi.*	*carinatus.*	*pinifolius.* *Elmeri.* *banayanicus.* *phlegmaria.* *salvinioides.* **borneensis.**	*nummulariifolius.*
Philippinen	**minimus.** *serratus.*	*verticillatus.*		*squarrosus.* **Magnusianus.** *Whitfordi.* **Toppingi.**	*carinatus.*	**Merrilli.** *pinifolius.* *Elmeri.* *banayanicus.* *phlegmaria.* *salvinioides.*	**Delbrückii.**
Neu Guinea	*serratus.*	*verticillatus.*	**bolanicus.**	*squarrosus.* **Hellwigi.** **Lauterbachi.**	*carinatus.*	**Dielsi.** **terrae.** **guilelmi.** **coralium.** *phlegmarioides.* **Ledermanni.** **flagellaceum.**	*nummulariifolius.*

Genus Lycopodium.

	Sectio.			
	Clavatostachys.	*Complanatostachys.*	*Cernuostachys.*	*Lateralistachys.*
Borneo		*scariosum.*	*cernuum.* *casuarinoides.*	
Philippinen	*clavatum.*	*complanatum.* *scariosum.*	*cernuum.* *casuarinoides.* *volubile.*	halconense.
Neu Guinea	*clavatum.*	*complanatum.* carolinianum.	*cernuum.*	

MERRILLOSPHAERA AFRICANA AT MANILA

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SEVEN PLATES

CONTENTS

INTRODUCTION

In preparing accounts of the larger Volvocaceae found at Manila I have left to the last a species that can be easily put in its place beside its nearest relatives in the family. This is the species that was described by West ('10) from Albert Nyanza, in Africa, under the name *Volvox africanus* and afterwards reported from the Ussangu Desert, also in Africa, by Rousselet ('14) who submitted material containing sexual coenobia to West for description (West, '18). This species, with others, was collected by Dr. M. A. Barber in the vicinity of Manila in July, 1914, and by myself at various later times, and is represented in my bottles, preparations, and micrographs by examples in most of the varied stages of the life cycle of the species, and with a diversity of form considerably greater than was shown by the material described by West from Africa.

Material associated with this species, and in most cases more or less abundantly mixed with it in the ponds, bottles, and preparations, led me to propose the separation from *Volvox* of those species in which the somatic protoplasts are without protoplasmic connecting filaments. Some of those species have their gonidia, the asexual reproductive cells, differentiated at an early

stage in the development of the asexually produced embryos, and they seem to form a natural group.

The most unique of these species exhibited a migration of the gonidia from the outside to the inside of the embryo through the phialopore shortly before the closure of that opening in the wall of the forming sphere. That species I have described (Shaw, '19) under the name *Campbellosphaera obversa.*

A species, so similar to *Campbellosphaera obversa* that for a long time the two were confused in my notes, was found to lack the migration of the gonidia and to possess other distinctive characters, and was proposed for the type of another genus, *Merrillosphaera* (Shaw, '22B). This species proved identical with *Volvox carteri* Stein ('78 *V. globator* Carter '59), and the largest Philippine form was described under the trinomial *Merillosphaera carteri* var. *manilana.* It was pointed out that *Volvox weismannia* (Powers, '08) is at most another variety of the same species, and that one of the forms described by Klein ('89B) from material collected by Migula may be regarded as another species under the name *migulae.*

In *Volvox africanus* from Albert Nyanza no protoplasmic connections between the protoplasts were observed by West ('10), and none have been found in my numerous collections of the species. My material reveals the fact that the gonidia are differentiated at an early stage of the embryonic development and attain a large size before segmenting in their turn, but do not migrate through the phialopore of the embryo. Mainly on the ground of these characters I assigned the species to the recently erected genus under the name *Merrillosphaera africana.*[1]

ORIGINAL DESCRIPTION AND ILLUSTRATIONS

The original description by West was based on asexual material obtained from Albert Nyanza by Mr. R. T. Leiper in 1907, and sent to West by Dr. W. A. Cunnington and Mr. C. F. Rousselet. It was illustrated by three photomicrographs (West, '10, pl. 3, figs. 8 to 10) that are herewith reproduced[2] on a larger scale (Plate 7, figs. 48 to 50). These show ovoid coenobia with dimensions, as indicated by the stated magnifi-

[1] A preliminary announcement of this was made in a footnote to a previously published paper (Shaw, '19, p. 512).

[2] Through the kindness of Prof. R. H. Yapp and Miss Nellie Carter, of the botanical department of the University of Birmingham, photographic prints from West's negatives have been provided for the reproduction of his figures with this paper.

cation, of about 455 by 525 μ, 420 by 490 μ, and 475 by 595 μ. The somatic cells show most clearly about the anterior poles where they are most widely spaced. In West's figure 10 (Plate 7, fig. 48) the somatic protoplasts are about 5 or 6 μ in diameter, and near the anterior pole they are spaced about 25 μ between centers. On the sides of the coenobium the spacing is about 19 to 21 μ. The number of somatic cells I estimate to be between 2,000 and 2,500. West described the cells as having no observable protoplasmic connections.[3]

The daughters, as shown by his micrographs, are three, four, and three, respectively, and the granddaughters two, two, and three in his figure 8 (Plate 7, fig. 49); four in one and probably all of the daughters in his figure 9 (Plate 7, fig. 50); and three, four, and four in his figure 10 (Plate 7, fig. 48). The latter figure shows within the granddaughters the fourth generation, but not sufficiently clearly for counting the great granddaughters or for determining whether they are gonidia or embryos.

The daughter coenobia, except when an odd one is present, occur in pairs and are compressed between their sisters and the wall of the mother coenobium. The mothers in West's figures 8 and 10 (Plate 7, figs. 49 and 48) have each one pair of larger and more-elongated daughters a little in advance of the middle of the mother, and an unpaired smaller daughter in the back part of the mother. Each of the larger, paired daughters is longer than half the length of the mother and narrower than half the width of the mother. As the transverse diameters which they show in the picture plane are shortened by compression against their sisters, their transverse diameters normal to the picture plane are probably considerably greater. The mother shown by West's figure 9 (Plate 7, fig. 50) has two pairs of daughters that lie in median planes normal to one another, the members of the pair near the middle being somewhat larger than those of the pair in the back, but all having dimensions considerably less than half as great as the corresponding measurements of the mother coenobium.

The granddaughters show the pairing also. One larger daughter in West's figure 8 (Plate 7, fig. 49) contains only a pair of globose granddaughters about 50 and 57 μ in diameter, this being about a quarter of the width of the daughter. They

[3] His mention in a later paper (West, '18, p. 426) of delicate connecting strands of protoplasm seems to have been a slip.

are located on opposite sides a little in advance of the middle of the daughter. There are three granddaughters in the other larger daughter and two in the smaller daughter; but, some of them being out of focus, their relative sizes do not show. In figure 9 (Plate 7, fig. 50) one of the daughters is clearly shown to contain four granddaughters and the others appear to contain the same number, all of which have diameters one-eighth or less of the dimensions of their mothers. The granddaughters in figure 10 (Plate 7, fig. 48) are four and three in the paired daughters, and four in the smaller daughter. The clearest picture of the fourth generation is one in the right member of the pair in the same figure, the globose granddaughter being about 65 μ in diameter, and the fourth generation, whether gonidia or embryos, about 12 μ in diameter.

The tendency to have the daughters grouped into a larger pair in the middle of the mother and a smaller pair farther back is probably more marked in the species than appears in the photomicrographs, and I believe that it may properly be regarded as a character of the species represented by the figures. West ('10) recorded having observed coenobia in which only a single daughter was present, and stated that in such cases the daughters were ovoid although free from compression by sisters.

A male coenobium observed by West ('10) in company with the asexual coenobia presented no means by which it could certainly be identified as of the same species. The material contained no female coenobia.

FEMALE COENOBIA FROM AFRICA

Female coenobia of this species were found in plankton material collected by Dr. A. W. Jakubski, of Lemberg, from small temporary pools in the Ussangu Desert, in what was then German East Africa, on his trip of 1909–10. Mr. C. F. Rousselet ('14), who discovered them, turned them over to West for description. In describing them West ('18) gave photomicrographic figures of two female coenobia with ripe oospores. These figures are reproduced herewith (Plate 7, figs. 51 and 52).

These coenobia are ovoid-ellipsoidal, and measure about 565 by 660 μ and 600 by 780 μ. Oospores are absent from the anterior fifth of the coenobium, and the number of oospores in each coenobium appears to be about 40 (39 and 41). West ('18) gave 70 to 80 (average 74) as the number of oospores in a coenobium. The number of cells in a coenobium he stated as 3,000 to 8,000 and the number of daughter coenobia as 1

to 4. The somatic cells are described as 8 to 9.5 μ in diameter, almost globose, with long delicate connecting strands of protoplasm. These connecting strands are mentioned only in a tabulation of characters of the species in contrast with characters of *Volvox rousseleti* which has relatively broad connecting strands. It appears to me that the ground for ascribing such connecting strands to this species was purely an assumption that, since they are present in a supposedly similar European species, they are therefore probably present in this one also.

The oospores measure about 45 μ in diameter and have thick smooth walls.

No male coenobia were observed that could be definitely connected with the species.

TYPICALLY OVOID COENOBIA AT MANILA

ASEXUAL COENOBIA

Philippine material that closely resembles the African coenobia described and figured by West was obtained from a small pond in Pasay, near Manila, October 19, 1914. This pond, designated by the letter I in my notes, was about half a meter deep and 6 meters across, and at that time it was shrinking, as the rainy season was drawing to a close.

Nine asexual coenobia from this material are shown in Plate 1, figs. 1 to 6, and Plate 2, figs. 7, 9, and 12. The first six of these contain only asexual progeny, and their pictures do not bring out any characters not given by West in his description of the African material. Direct observation of the specimens, however, brings out the fact that most of the third generation that is represented in these coenobia are still undivided gonidia. The oldest of the six is the only one in which gonidia of the daughters have divided, and in that one there is an undivided gonidium in each daughter.

Study of the specimens reveals another point that was not brought out by West. In coenobia with less than two pairs of daughters or gonidia, absent members that would be required to make up this number are commonly represented by abortive gonidia which are located in the places where, from the arrangement in cases where two pairs are present, gonidia would be expected to occur. Some notes on these specimens will now be recorded.

Specimen 1.—Plate 1, fig. 1. This is an asexual coenobium with one daughter containing two gonidia. In the picture a

vacancy can be seen in the layer of somatic cells opposite the daughter. The slide bearing this specimen dried up before it was studied closely.

Specimen 2.—Plate 1, fig. 2. This is an asexual coenobium with two daughters, each with a gonidium of 53 μ in its left side and an embryo in the right side. The embryo in the left daughter is 8-celled and measures 54 μ, and that in the right daughter is 2-celled and measures 53 μ. On the nearer and the farther sides of the mother, at the level of the lower ends of the daughters, near the median plane of the picture, there is a cell with the protoplast about twice the size of a somatic protoplast sunken beneath the level of the somatic layer. The positions of these two cells indicate that they are a posterior pair of abortive gonidia. There is a similarly enlarged protoplast in the wall of the mother over that part of the left daughter midway between the reproductive bodies and the lower end. This protoplast is not sunken below the level of its neighbors, possibly because of interference by the daughter. In the daughter at the left there are two small reproductive bodies that do not show in the photograph. They are in the hindmost (lower) half of the coenobium and measure about 12 μ wide. One is nearer the hinder pole than is the other, and they are both nearly in the same plane with the larger reproductive bodies. In the hinder (upper) part of the right daughter there are three diminutive reproductive cells smaller than those in the left daughter. This specimen and the other larger ones of this series are greatly flattened and broadened by the cover glass.

Specimen 3.—Plate 1, fig. 3. This is a somewhat younger asexual coenobium with two asexual daughters, each having three prominent gonidia. The gonidia measure 60, 57, and 46 μ in the left daughter and 53, 53, and 42 μ in the right daughter. In the mother coenobium, midway between the lower ends of the daughters and the hinder pole of the mother, there are two abortive reproductive cells, one a little more and the other a little less than twice the diameter of their neighboring somatic cells below the level of which they are sunken. Between the nearer abortive body and the lower end of the left daughter there is a group of three somatic cells that are enlarged to about one and a half times the diameter of the neighbor cells. But they are not sunken. In each daughter there is, besides the prominent reproductive bodies, a small one of about 11 μ near each of the large ones. The small body in the back

part of the daughter may be a vestigial mate of the larger one, and the two near the middle may be a vestigial second equatorial pair of gonidia.

Specimen 4.—Plate 1, fig. 4. This is an asexual coenobium with a pair of daughters, each containing two pairs of gonidia. It was in a preparation that dried before being closely studied.

Specimen 5.—Plate 1, fig. 5. This is another asexual coenobium with two daughters. The one at the left contains two pairs of gonidia, and the one at the right contains a pair of larger gonidia and a single smaller one. The specimen was ruined by a bubble before being examined for abortive reproductive bodies.

Specimen 6.—Plate 1, fig. 6. This is an asexual coenobium with a pair of larger daughters and a single smaller one. The mother contains also, on the farther side and partly hidden by the smaller daughter, a reproductive body about 18 μ wide that appears to be divided into four cells. It is in the position that would have been occupied by the mate of the smaller daughter had there been one developed. In the right daughter there are two and in the lower daughter there is one of the abortive reproductive bodies in addition to the large ones that appear in the picture.

Specimen 7.—Plate 2, fig. 7. This is an asexual coenobium containing a bisexual, a male, and an asexual daughter. The bulging of the sides of the mother is partly due to flattening under the cover glass. The asexual daughter contains three prominent gonidia, two of 55 μ and one of 35 μ. Damage by the crowding of a bubble has made it impossible to look for a vestigial mate of this smaller daughter. The asexual daughter is headed backward and the others are headed forward, and all show absence of reproductive bodies in their anterior ends. The sexual daughters will be described under another heading.

Specimen 8.—Plate 2, fig. 9.[4] This is an asexual coenobium with two daughters, one sexual and the other asexual. The mother has, on the nearer and the farther sides on a level with the lower ends of the daughters and in the median plane of

[4] The unfortunate arrangement of the figures that illustrate this paper in a different order from that in which the specimens are treated in the paper resulted partly from a decision to use a uniform magnification of one hundred diameters, partly from a war-time effort to economize plate area. After the plates had been made up there accumulated notes that refer to the figures by number and render it undesirable to alter their arrangement.

the picture, an abortive gonidium with diameters about two and a half times as great as those of the neighboring somatic protoplasts. They are sunken below the somatic layer. The asexual daughter contains two embryos and one gonidium. The gonidium is the smaller body and measures about 46 μ. It has a very small vestigial mate of about 7 μ. The embryos are about in the 8- and 4-celled stages. Their details do not show very clearly through the coenobium walls of the mother and the daughter. The female daughter will be described under another head.

Specimen 9.—Plate 2, fig. 12. This is an asexual coenobium with three sexual daughters in which female reproductive bodies predominate. The daughters are all headed forward with the mother, and all show absence of reproductive bodies in their forward parts. On the farther side of the mother, on a level with the middle of the smaller daughter, there is an abortive gonidium of about 13 by 16 μ. The daughters will be described with the female coenobia. On the same slide with this specimen there is another with three female daughters of similar proportions and one with four that form a pair of larger and a pair of smaller ones.

These nine specimens illustrate the fact that in this material the asexual coenobia bear from one to four gonidia that are already large in embryonic coenobia and reach a very great size before dividing. When four are present they form two pairs, a pair of large ones on opposite sides of the middle of the coenobium and a pair of smaller ones on opposite sides of the hindmost half, third, or quarter of the coenobium and in or near a longitudinal plane normal to the longitudinal plane passing through the other pair. When only three gonidia are present it is usually one of the smaller pair that is absent, and when only two are present it is usually both of the smaller pair that are absent. When only one is present it is usually one of the larger pair, and the daughter produced occupies only its own side of the mother. The absent members, when less than four are present, are represented by what may fairly be regarded as abortive gonidia of about one and a half to three times the diameter of the somatic protoplasts, that are formed in the coenobium wall at places where gonidia would be expected and sink below the level of the neighboring somatic cells. Indications are not wanting that some of these coenobia contain traces of a third pair of gonidia located in nearly the same

transverse plane as the larger gonidia. These were noted in both daughters of specimen 3.

FEMALE AND BISEXUAL COENOBIA

The above heading was written before it had become apparent that the coenobia for which it is intended are not all strictly female, since some of them contain a few antheridia. It will be convenient to consider here those coenobia in which the female reproductive bodies greatly preponderate. Observations on the unborn daughters in the last three specimens will first be recorded.

Specimen 7a.—Plate 2, fig. 7. The female daughter in this specimen contains twenty-three oogonidia that range from 25 to 29 μ, and three reproductive bodies that I take to be androgonidia. Two of the latter are undivided and measure about 18 μ, and the other is divided into four cells and measures about 21 μ. The undivided supposed androgonidia are the two smaller bodies, one to the left and above the center, the other to the right and below the center. The first is on the nearer side, the other on the farther side of the coenobium. Their positions are about those of a typical pair of larger gonidia in an asexual coenobium. The third supposed androgonidium is farther back and to the left. Examination of the preparation from the back of the slide revealed, in the place that would be occupied by a symmetrically placed mate to the dividing androgonidium, a reproductive cell of about 20 μ in diameter.

Specimen 8a.—Plate 2, fig. 9. The female daughter in this mother contains twenty-three oogonidia of 21 to 28 μ in diameter, and two reproductive cells of about 18 μ in diameter. The latter are the bodies at the extreme right and left in about the middle of the coenobium. They are obviously homologous in position with the larger reproductive bodies of the asexual sister coenobium. In all probability they are androgonidia.

Specimens 9a, 9b, and 9c.—Plate 2, fig. 12. The three female daughters of specimen 9 contain thirty, seventeen, and twenty-nine reproductive bodies. In the two larger daughters two of the bodies are androgonidia, of which those in one coenobium are divided. In the left daughter (*9a*) the androgonidia are the upper, obscure member of a pair at the extreme left of the coenobium, and the lower member of a triad at the extreme right of the coenobium. They are fairly symmetrically located on opposite sides of the middle of the coenobium. These two

androgonidia measure about 18 μ, and the twenty-eight gonidia measure 21 to 28 μ. In the right daughter (9*b*) the androgonidia are the obscure smaller member of a pair at the left, and the smaller body at the right side of the middle of the coenobium. The one at the left is 4-celled and measures 21 μ, the one at the right is 2-celled and measures 18 μ. The fifteen oogonidia are 21 to 28 μ wide. In the small daughter (9*c*) the twenty-nine reproductive bodies measure from 18 to 21 μ. No androgonidia are distinguishable.

Specimen 10.—Plate 2, fig. 11. This is a free bisexual coenobium that is immature. It contains twenty-nine oogonidia of about 30 μ in diameter and two androgonidia. Of the latter the one at the left is on the farther side a little above the middle. It is divided into an immature platelet of thirty-two cells that measures 26 μ across. The one at the right is on the near side and is obscured by being in front of the upper member of the twin oogonidia at the extreme right of the coenobium. It is about 19 μ in diameter. In this coenobium there are numerous cells that are larger than typical somatic cells distributed like androgonidia in a male coenobium. They measure about 8 μ, and the somatic cells 4 to 6 μ.

Specimen 11.—Plate 2, fig. 10. This is a nearly mature sexual coenobium with twelve oospores that range from 39 to 43 μ wide. They have smooth spore walls that appear to be about 3 μ thick. Unfortunately, the specimen has become too much crushed by a bubble to admit of determining whether antheridial sites are present.

Specimen 12.—Plate 3, fig. 15. This coenobium contains about twenty-seven oospores that can be counted in the photograph. Each of the four spores that are black in the picture has another behind it. The preparation dried up before the specimen was studied in detail. One of the spores is shown more highly magnified in Plate 3, fig. 16. Its diameter is about 40 μ. This spore is the upper one on the left side of the coenobium. In the photograph two somatic protoplasts below the left side of the spore are in fairly sharp focus. The cells that look like ghosts are below the focal plane and those that show as dark shadows are above that plane. Although the spore appears to be in sharp focus it was probably somewhat below the focal plane. This is indicated by the fact that the somatic cells most nearly in focus are on diametrically opposite sides of the spore. To the right from the spore there is a vacancy

in the somatic layer; in fact, there appears to be a pair of such vacancies, of the sort that mark antheridial sites.

Specimen 13.—Plate 3, fig. 17. This coenobium contains thirty-one oospores by count under the microscope. There appears to be an antheridial site a little above and near the center of the picture. Examination from the back of the slide revealed a similar vacant space on the opposite side of the coenobium. There is a similar vacancy halfway to the left side and a little below the middle of the coenobium. It is obscured by a spore directly behind it on the opposite side of the coenobium. The oospores have smooth walls of about 41 μ in outside diameter and about 2 μ in thickness, and contain a protoplast of which the denser portion is about 33 μ in diameter. Four of the spores are shown more magnified in Plate 3, fig. 18. A slightly wavy appearance is produced by the shadows of overlying somatic cells.

Specimen 14.—Plate 6, fig. 46. This is an immature coenobium containing thirty-two oogonidia of about 37 μ in diameter and an antheridium consisting of a sperm platelet. This sperm platelet is a little above and to the left of the center of the picture. The platelet consists of sperms, but whether the group is still complete, and whether nearer to sixty-four or to one hundred twenty-eight, I am unable to make out. On the opposite side of the coenobium there is an empty antheridial site that is symmetrically located with reference to the antheridium.[5] Below the middle of the coenobium and halfway to the left there is another vacancy like an antheridial site.

Specimen 15.—Plate 6, fig. 47. This is the most mature of all the female coenobia figured. Like all the other coenobia of this series it is very much compressed under the cover glass, having a thickness of only about 56 μ. It measures 545 by 650 μ, being longer and broader than when the picture was taken. It then measured 515 by 620 μ, and its dimensions before compression were probably nearer 500 by 600 μ. The spacing of the somatic cells ranges from about 23 μ forward to about 10 μ at the back. Taking 570 μ as a mean diameter and 14 μ as the average spacing of the cells, we get 6,000 as the number of cells. This may be too high on account of the flattened condition of

[5] This was overlooked until the preparation was studied from the back by the use of a Zeiss achromatic objective B (12 millimeters equivalent focus).

the coenobium. There are twenty-seven oospores in the coenobium. They have smooth walls that measure about 43 μ in outside diameter and about 37 μ in inside diameter. Some of the oospores that appear in pairs are on the same side of the coenobium, and some are on opposite sides. Some of the closest pairs are on the same side, but so far as can be made out they do not arise from contiguous cells in the somatic layer. They are, therefore, not sister cells. At the middle level of the coenobium there is an antheridial site on the nearer side a little to the left of the oospore at the extreme right, and another on the farther side a little to the right of the oospore at the extreme left. On the farther side there is also an antheridial site just to the right of the foremost member of the left hindmost pair of oospores.

TABLE 1.—*Reproductive contents of some preponderatingly female coenobia of Merrillosphaera africana at Manila.*

Specimen No.	Oogonidia or oospores.		Androgonidia, antheridia, or sites.	
	Number.	Size.	Number.	Size.
		μ.		μ.
9*c*	29	18-21	0	----------
9*a*	28	21-28	2	18
9*b*	15	21-28	2	18
8*a*	23	21-28	2	18
7*a*	23	25-29	3	19
10	29	30	2	19
14	32	37	2	----------
12	27	40	(?)	----------
13	31	41	3	----------
11	12	39-43	(?)	----------
15	27	43	2	----------

In this little series of coenobia with preponderatingly female reproductive bodies the number of oogonidia or oospores ranges from twelve to thirty-two as is shown in Table 1. Their greatest size before birth is about 29 μ. The ripe oospores are about 43 μ wide with a wall about 3 μ thick. Reproductive bodies are absent from the front of the coenobia. The androgonidia are two or three. Two form a pair, located on opposite sides of the middle of the coenobium, as are all of the larger gonidia of asexual coenobia. The androgonidia reach a size of only about 19 μ and divide before the birth of the coenobium containing them. The antheridium is a sperm platelet.

MALE COENOBIA

Coenobia that contain, besides the somatic cells, only large numbers of androgonidia that divide to form bundles or platelets of sperms were first described by Ehrenberg under the name *Sphaerosira volvox.* Since it has been recognized that these are the male coenobia of species of *Volvox* they have been known as the *Sphaerosira* stage of the species in which they occur.

That male coenobia of the *Sphaerosira* type occur in *Merrillosphaera africana* is demonstrated by specimen 7, in which asexual, bisexual, and male progeny occur in the same mother coenobium. Since the two species of *Merrillosphaera* occur mixed in most of the collections, description of the unborn males in their distinguishable mothers is more important than description of the free males concerning the identity of which there may be question. The only male coenobium in this little series of photomicrographs of typically ovoid coenobia at Manila will now be described.

Specimen 7b.—Plate 2, fig. 7. The unborn male coenobium in specimen 7 is of the same size and shape as its twin sister. It measures 265 by 383 μ in its flattened condition. The average spacing of the cells is between 21 and 25 μ. Taking it as 22.5 μ and the mean diameter of the coenobium as 302 μ, the number of cells indicated would be 6,500. The size of the somatic protoplasts ranges from about 4.5 μ at the back to about 7 μ at the front. The protoplasts of the twin sister coenobium are of the same size. Those of the smaller sister are all about 4 μ. Those of the mother coenobium range about from 6 to 7 μ. The area in the front that contains no androgonidia is small. The androgonidia are about from 12 to 15 μ wide and all undivided. It is estimated that in a given area they are about five times as numerous as the oogonidia of the twin sister. This indicates a number of about one hundred fifteen. They are scattered rather irregularly under the coenobium wall. Some are in pairs that are in contact, some in rows of three, and some form chains of cells that are not far apart.

The free male coenobium shown in Plate 2, fig. 8, is not from the same source as the material described. It will be considered with its associates as specimen 24.

FORMS WITH SOMETIMES MORE THAN FOUR GONIDIA

A FORM WITH SOMETIMES SIX GONIDIA

From the same pond, I, that supplied the material that included the specimens already described, there was obtained two

weeks earlier, October 5, 1914, material that has the distinguishing feature of embracing coenobia with six gonidia. Examples of these will be given as specimens 16 to 24. From a neighboring pond, J, on October 13 there was obtained material that included specimens 25 and 26, which also exhibit six gonidia. The slide bearing specimens 16 to 25 dried up before these coenobia were studied in detail. The specimens will be separately described for the purpose of bringing out points that may show better in the photographic prints than in the plates.

Specimen 16.—Plate 2, fig. 13. This is an asexual coenobium with two embryo daughters and two gonidia. The embryos are near the middle of the coenobium, one a little ahead of and the other a little behind it. They have the phialopores open. The gonidia are near the hindmost end of the coenobium.

Specimen 17.—Plate 4, fig. 21. This is another asexual coenobium in the same preparation. It contains two daughters and two very young embryos in pairs. So far as can be seen the reproductive bodies, gonidia, in the daughters are in number, relative size, and arrangement like those of the mother.

Specimen 18.—Plate 3, fig. 14. This is a specimen that was photographed on the same plate with specimen 16. It is an asexual coenobium with six reproductive bodies arranged in pairs. Two are embryos with their phialopores still open. They form a pair on opposite sides of the middle of the coenobium. Each of the other pairs of reproductive bodies consists of a gonidium and a few-celled embryo. One pair is a short distance back of the middle of the coenobium and nearly forms with the pair of daughters a square. The left body of this pair is the gonidium, and the right one the young embryo. The third pair is near the back of the coenobium; the left member is the embryo, and the right one is the gonidium. The diameters of the gonidia are about 50 μ.

Specimen 19.—Plate 4, fig. 23. This is a nearly mature asexual coenobium with six reproductive bodies that have proportions and arrangement similar to those of specimen 18 (fig. 14). Two pairs of larger but unequal daughters form a square in the middle, and one pair of smaller daughters is in the back part of the mother behind the members of the smaller middle pair. The conspicuous reproductive bodies in the daughters appear to be six gonidia in each of the middle daughters and four gonidia in each of the hinder pair. The gonidia of the larger daughters are proportioned and arranged like the daugh-

ters in the mother. Those of the smaller daughters are in two pairs like those of specimens 16 and 17 (figs. 13 and 21).

Specimen 20.—Plate 4, fig. 25. This is a similar but more-mature asexual coenobium. It contains a pair of larger, a single intermediate, and a pair of smaller daughters. All of the daughters appear to have four reproductive bodies except the left smaller one, which contains five. Whether the mother formed five daughters, or whether it had six, of which one had been born when the material was fixed, we cannot determine. In the former case it would resemble specimen 19 (fig. 23); in the latter it would resemble its pentagonidiate daughter.

Specimen 21.—Plate 4, fig. 24. This asexual coenobium and the next represent a form that presents a very different appearance from that of typical *Merrillosphaera africana.* The progeny are all practically of the same size. In these cases they happen to be male coenobia, each containing many androgonidia, or female.

Specimen 22.—Plate 4, fig. 26. An asexual coenobium with four female daughters. The daughters are so nearly of the same size that the gonidia from which they developed were probably nearly enough alike for the coenobium to be termed isogonidiate.

Specimen 23.—Plate 4, fig. 22. This is a female coenobium that contains, so far as we can see by the picture, twenty-five oogonidia. It measures 260 by 330 μ, and the oogonidia are about 27 μ wide.

Specimen 24.—Plate 2, fig. 8. This is a male coenobium with a large number of androgonidia. It is impossible to determine from the photograph whether or not the reproductive cells had divided. The vegetative area, if any, at the front of the coenobium is small. The coenobium measures about 270 by 350 μ, and the androgonidia are about 10 μ wide.

Specimen 25.—Plate 4, fig. 20. This and the next specimen were taken from Pond J, on October 13, 1914. This coenobium contains four daughters and one gonidium. The left of the larger daughters contains a pair of larger gonidia and a small one; the right one contains a pair of larger gonidia and a pair of smaller ones. Behind the right daughter there is an odd daughter that contains two larger and two smaller gonidia. In the back of the mother there is a small daughter containing likewise two larger and two smaller gonidia. This daughter is paired with a gonidium 54 μ in diameter. It may be noted

that the smaller daughter and the gonidium lie in a longitudinal plane perpendicular to that which passes through the larger daughters.

Specimen 26.—Plate 3, fig. 19. This is a nearly mature coenobium of the same preparation as the preceding. It measures 350 by 420 μ. The average spacing of the cells is about 12 μ, and the number of them is about 3,500. The protoplasts are ovoid and range about from 6 to 7 μ. The mother contains two elongated daughters that occupy the middle and back parts of the coenobium. Even with the hindmost ends of the daughters there are in the mother two abortive gonidia, one on the farther side and one on the nearer. These are about twice the size of somatic protoplasts and are sunken below the somatic layer. The daughters measure 110 by 160 μ and 90 by 105 μ. The larger one contains two granddaughters of 65 by 75 μ each, with a pair of gonidia measuring 48 by 50 μ and 40 μ near the middle and another pair of 50 μ and 42 μ near the hind end. The nearer granddaughter contains two larger and two smaller gonidia. The contents of the other are obscure. The smaller daughter contains two granddaughters and two gonidia of 45 μ each. One granddaughter contains two larger and two smaller gonidia, and the other is in an embryonic or pathologic condition with the phialopore wide open. Near the middle of the daughter there is a symmetrically disposed pair of rudimentary gonidia about 9 μ in diameter. Such a middle pair of vestigial gonidia is clearly lacking in the mother coenobium. On the same slide there are specimens with other combinations of daughters and granddaughters, and they include hexagonidiate coenobia that are more nearly mature and more nearly globular.

Specimen 27.—Plate 5, fig. 31. From Pond C in Pasay on September 20, 1914, material was taken of which some was fixed on the day of collection and some on the following day. Specimen 27 is among the latter. This is a very symmetrical hexagonidiate coenobium measuring 410 by 450 μ.[6] The protoplasts measure about 4 to 5 μ. The number of cells is about 5,000. The daughters of both middle pairs contain six gonidia each. The posterior daughters contain four gonidia each, and

[6] Five and a half years after the photograph was taken the dimensions had increased to 500 by 515 μ. Whether this is all due to additional compression or partly due to hydration of the membranes it is impossible to decide. The magnification of the figure is checked by a photograph of a stage micrometer that was made on the same plate with the same combination of photographic apparatus.

in each an abortive gonidium is visible, and there may be another in an obscure part. Between the two posterior daughters, on each side of the mother there is a cell somewhat larger than the somatic cells that may be interpreted as an abortive gonidium. One is about twice the diameter of a somatic cell and sunken, the other is about one and a half times the diameter of a somatic cell and not sunken.

Specimen 28.—Plate 5, fig. 32. This specimen is from the same material as the preceding but fixed on the first day mentioned. It has undergone partial disintegration since being photographed. It contains a pair of larger and a pair of smaller daughters, which in turn contain four gonidia each. The measurements of the gonidia are: 12.5, 13, 11, and 11 μ; 13, 13, 12, and 12 μ; 8.5, 9, 10, and 10 μ; and 8.5, 9, 9.5, and 9.5 μ.

Specimen 29.—Plate 5, fig. 37. From the same pond as the foregoing, about a month later, there came the material that included this specimen. It is very similar to the preceding specimen, but two of its four daughters are female. The asexual daughters contain, in the larger, two 8-celled and two 4-celled embryos; in the smaller, two 4-celled embryos and one gonidium in its first division and measuring about 46 μ. The female coenobia contain twenty-three reproductive bodies of 20 to 25 μ and twenty-four reproductive bodies of 18 to 23 μ, respectively.

Specimen 30.—Plate 5, fig. 33. This specimen and the two following are from the same material as specimen 27 (Plate 5, fig. 31). They were on a slide that dried up before notes were taken on the contents of the daughters. Specimen 30, a coenobium of 325 by 360 μ, contains two pairs of daughters, those of one pair somewhat larger (120 by 125 μ) than those of the other (90 by 100 μ). The contents of the daughters seem to be of the same type as of the mother.

Specimen 31.—Plate 5, fig. 34. This specimen shows a not uncommon combination of three larger and one smaller daughters. It is impossible to decide from the picture whether the smaller body in this case is a daughter or a gonidium. It measures about 50 μ.

Specimen 32.—Plate 5, fig. 36. This was selected as an example of coenobia having four daughters of nearly the same size. They are plainly arranged in pairs.

Specimen 33.—Plate 4, fig. 29. This is from the same lot as specimen 28 (Plate 5, fig. 32) and others. The mother is rather mature, and the daughters are backward in development.

There are two daughters and one embryo of sixteen cells. The daughters measured about 75 μ each, one containing gonidia of 22, 22, 16, 8, and 8 μ and the other of 25, 23, 8, 8, and 8 μ. The somatic cells of the daughters are ciliated and measure about 3.6 μ and are almost in contact. The number of cells in each daughter is about 1,570.

Specimen 34.—Plate 5, fig. 30. This was taken in September, 1914, from a carabao wallow, A, about 400 meters from the ponds previously mentioned. It contains four daughters, each with a pair of larger and a pair of smaller gonidia. In one of the larger daughters one of the smaller gonidia is extra small. The protoplasts of the daughters are about 5 μ wide and seem to be forming cilia.

Specimen 35.—Plate 5, fig. 38. This and the next coenobium are from carabao wallow B, near the one called A, in September, 1914. The specimen had dried up before being studied. However, the photograph is sufficiently clear to enable me to identify the contents of the daughters. Of the four daughters one is larger and the others are of nearly equal size. Each daughter contains two larger and two smaller gonidia, except one in which one of the smaller gonidia is extra small. In the smallest daughter two of the gonidia lie nearly one behind the other.

Specimen 36.—Plate 5, fig. 35. This is a young coenobium from the same slide as the preceding specimen. It contains at the left an advanced sexual embryo with the phialopore open. In the back there is a young asexual embryo with the phialopore open, and at the right there is an asexual embryo intermediate in development between the other two with the rim of the phialopore rolled outward and backward.

Specimens 37 and 38.—Plate 4, figs. 27 and 28. These are young coenobia with five and four embryonic daughters of which the phialopores are open. The specimens were crushed by glass rodlets that were intended for holding up the cover glass.

A FORM WITH SOMETIMES EIGHT GONIDIA

The largest number of asexual reproductive bodies in any of the specimens described in the preceding paragraphs is six, and their arrangement is in three pairs when that number is present. In material from the same collection as specimen 19 (Plate 4, fig. 23) I have seen, in a Venetian turpentine preparation that was stained too lightly for photography, one asexual coenobium with seven reproductive bodies. In this case the

additional member was a small gonidium in the back part of the coenobium. A collection made at Pasay on September 22, 1915, contained an abundance of a form that very commonly contains six, seven, or eight gonidia. It also contains smaller numbers, and when four are present they may be two slightly unequal pairs at about the same level, or one pair may be in the middle and a smaller pair in the back of the coenobium. Four specimens used in illustrating this material will show something of the range of the number of gonidia in this form by the gonidial content of their daughters.

Specimen 39.—Plate 6, fig. 39. This is a rather unique coenobium with six daughters arranged symmetrically in pairs. Only two of the daughters bear developed reproductive bodies. In each of these there is only one gonidium. There are a few very small reproductive cells in some of the daughters. It may be that these empty coenobia were to become males, but it seems to me that they were not preparing for any reproduction.

Specimen 40.—Plate 6, fig. 40. This coenobium had seven gonidia, of which six produced three symmetrical pairs of daughters and one a 16- or 32-celled embryo. The measurements of the mother are 320 by 400 μ.[7] The protoplasts are globular and measure from 5 μ at the back to 7 μ at the front. The average spacing of the cells appears to be about 10.7 μ and the number of cells about 3,800. The daughters by pairs are 150 by 170 μ and 142 by 160 μ, 125 by 138 μ and 125 by 145 μ, and 105 by 100 and 110 by 118 μ. The embryo, which has no mate, is about 55 μ wide and forms a hollow sphere with a small phialopore. The nuclei of all the cells of the sphere are at or near the inner ends of the cells. The daughters all contain gonidia. In the largest there are six of these: a pair of large ones, 55 by 58 μ and 53 by 57 μ; a pair of smaller ones nearly in the same plane as the first pair, 28 and 26 μ; and a pair intermediate in size, 41 and 35 μ, at the back of the coenobium. The mate to the largest daughter and one of the second pair each have a pair of large gonidia and two other pairs consisting of a medium and a smaller one. The other member of the second pair has a pair of large gonidia and a small odd one near the middle, and a medium and a small one at the back. The two

[7] In the photographs taken in 1916, the measurements of this coenobium are 350 by 460 μ. It is evident that these specimens in Venetian turpentine have shrunken until, in 1921, this one measures, under the microscope, 320 by 400 μ. That there has been shrinkage is made evident by the fact that the daughters in the coenobium are now nearer together.

small daughters have each four gonidia, in two pairs, large and small.

Specimen 41.—Plate 6, fig. 41. This is a coenobium that had eight gonidia that were arranged in four symmetrical pairs of different sizes. Those of the largest and next largest formed a square in the middle of the coenobium. Those of the third pair are behind and alternating with those of the two pairs in the middle of the coenobium. Those of the fourth pair were somewhat behind the members of the largest pair and were farther back than the third pair. The mother coenobium measures 350 by 370 μ.[8] The spacing of the cells averages about 10.7 μ. The number of cells is about 3,900. The protoplasts are globose and about 5 μ wide in the back and 7 μ wide in the front. The daughters are more nearly equal in size than those in the preceding specimen. Measurements of one of each pair are: 145 by 155 μ and 125 by 125 μ for the two pairs in the middle, 112 by 115 μ for the pair at the back, and 60 by 60 μ and 60 by 65 μ for the embryos. The pair of largest gonidia of each of the daughters in the middle group measure 50 μ; those of the daughters in the back of the mother, 46 and 39 μ. In the largest daughters there are six and five gonidia, and in the others four with the addition of one or two vestigial gonidia. The embryos are hollow spheres with open phialopores. The one nearest the observer consists of about one hundred sixteen cells. The somatogenic cells are about 7 by 9 μ in surface view. Two gonidia that can be measured are about 18 μ and 14 μ wide, the latter being nearer the phialopore. The indications are that the gonidia were formed at the 32-cell stage and showed their differentiation by not dividing when the somatogenic cells divided.

Specimen 42.—Plate 6, fig. 42. This coenobium is very similar to the preceding. It has six daughters in which the gonidia are in pairs and range from four to six with one or two vestigial gonidia in some of the cases, including both of those with six gonidia.

The forms here described with six, seven, and eight gonidia present no characters in the numbers, combinations, or arrangement of asexual reproductive bodies by which they can be distinguished from *Merrillosphaera africana*. Specimens 39 to 42, inclusive, are from a collection in which the coenobia were very abundant, formed almost a pure culture of the species, and presented a great variety of stages. A scanning of a preparation

[8] The dimensions in 1916, as indicated by the photograph, were 400 by 445 μ.

shows that the gonidia of the daughters almost all remain undivided until after the birth of the daughters. In some mothers there are four daughters that form a group without room for more behind.

There is an abundance of sexual and male coenobia in some material from the same source as specimens 16 to 24. The best of this is mounted in Venetian turpentine and stained too lightly for photomicrography.

One sexual coenobium similar to those of typical *Merrillosphaera africana* has five antheridia that are distributed in the coenobium to form two pairs near the middle and an odd one in a lateral position at the back. The arrangement is like that of gonidia in an asexual coenobium. Each of these antheridia forms a shallow cup of sperms or spermatogenous cells.

A small sexual coenobium was noted in the same mother with a somewhat smaller sister that contains two gonidia about 60 μ in diameter. This sexual coenobium contains twelve oogonidia and three androgonidia, the latter all in process of division and distributed like gonidia in an asexual coenobium, two in the middle and one at the back. The paired ones are 2- and 8-celled, and the odd one is 4-celled. The oogonidia measure about 32 μ.

Relatively mature oospores measure 35 to 39 μ. In these Venetian turpentine preparations none of the spores show any thickness of the spore wall.

Mixture of sexual and asexual reproductive bodies in the same coenobium was observed only once. In that case the coenobium contains three daughters and five oogonidia. The daughters are a pair in the middle and one at the back. Four of the oogonidia are grouped in that hind quarter of the coenobium left vacant by the lack of a mate to the smallest daughter. The fifth oogonidium is in advance of the middle daughters. The mother is 250 by 320 μ; the largest daughter is about 100 μ, and the smallest about 75 μ. The oogonidia range from 30 to 35 μ. The largest daughter contains four gonidia of from 18 to 22 μ. Its mate is somewhat smaller and contains three gonidia.

A SMALL FORM

A small form that is sometimes mixed with other species and sometimes forms almost pure cultures in the water has not been fairly represented in the micrographs that have been made. The only pictures of it are from the margins of plates used for larger species. They happen to be from Pond Q in Pasay on October 2, 1915. It is believed that they represent a diminutive

form that the species takes under conditions unfavorable to the development of robust coenobia. These specimens are in Venetian turpentine and considerably shrunken. In some lots in the same medium there appears to be very little shrinkage. The figured specimens (43 to 45) and some others (46 to 52) will be described.

Specimen 43.—Plate 6, fig. 43. This is a female coenobium with about twenty oospores of about 35 to 39 μ. It measures only about 200 by 240 μ.

Specimen 44.—Plate 6, fig. 44. This is an asexual coenobium with two daughters each containing two large gonidia and in one a third, very small gonidium. The mother is only about 150 by 160 μ, the daughters about 70 by 80 μ, and the gonidia about 15 μ.

Specimen 45.—Plate 6, fig. 45. An asexual coenobium with two daughters, each containing two large gonidia and one or two vestigial gonidia. The mother is 170 μ wide and 165 μ long; the daughters are about 80 by 100 μ; and the gonidia are about 25 μ in diameter. The polar regions of the mother coenobium are greatly shrunken by the mounting medium in this as well as in the preceding specimen.

Specimen 46.—Not figured. In a different lot of material, associated, apparently by accidental admixture, with forms resembling specimens 39 to 42, that are not shrunken in mounting, there is a coenobium of the same kind as specimens 44 and 45 having an even more-compact appearance. It measures 170 by 180 μ, has two daughters of about 80 by 120 μ, and in each two gonidia of from 42 to 50 μ.

The small forms are very abundant in collections IV and V made at Pasig, near Manila, in August, 1914. Some descriptive data pertaining to six coenobia of this material will be recorded here. The first five are in Venetian turpentine, and the last is in glycerine. A comparison of the material in the two media seems to show that there is more shrinkage in the Venetian turpentine than in the glycerine.

Specimen 47.—This is a mother coenobium that was selected because it was thought to contain only one daughter. Closer examination revealed the outer outline of the capsule of an absent daughter. This capsule is a little shorter than that of the present daughter. No place of exit of the absent daughter could be seen. The remaining daughter occupies a little more than its share of the space within the mother. The mother measured 170 by 180 μ. It consists of about 5,300 cells packed closely to-

gether with a spacing of about 4.5 μ. It has not been free more than a short time. The daughter is 105 by 110 μ with cells closely packed and spaced about 3.5 μ. The number of cells indicated is about 3,400. It contains two developed gonidia and some vestigial ones. The gonidia are 50 by 55 μ and 48 by 52 μ, and their combined diameters reach entirely across the cavity of the daughter, so that the gonidia are in close contact in the center.

Specimen 48.—This is a mother with two daughters each having two gonidia. The mother is much wider than long, 220 by 170 μ. The daughters are 120 by 140 μ and 115 by 135 μ. The gonidia in the daughters are 70 and 75 μ in one and 68 by 76 and 65 by 70 μ in the other. These are the largest gonidia recorded in this paper.

Specimen 49.—This is a mother with two asexual and one female daughters. The mother is 270 μ wide and 240 μ long. The daughters are 130 by 140 μ. They contain two gonidia in two and twenty-five oogonidia in the other. The dimensions of the gonidia are 60 by 67 and 65 by 70 μ in one and 68 by 70 and 65 by 67 μ in the other daughter. The oogonidia are about 16 μ wide. In the first daughter one gonidium is dividing, and the other is about to divide as shown by the nuclei. Before dividing the nucleus moves from the center to the outward side of the gonidium.

Specimen 50.—This is an asexual coenobium with three daughters; a pair of larger ones that are male and female, and a smaller one that is female. The mother measures 190 by 230 μ, the male coenobium 130 by 140 μ, and the females 130 by 150 μ and 90 by 120 μ. In the larger female the oogonidia number twenty-seven and measure 18 to 25 μ, and in the smaller one there are eighteen oogonidia that measure from 12 to 18 μ. In the male coenobium the androgonidia are about 9 to 11 μ in diameter, and they are so numerous that they form an almost continuous layer, except in a small area in the front of the coenobium where there are none. The number of the androgonidia is about three hundred fifty.

Specimen 51.—This was selected as an example of a rather small female coenobium. It measures 165 by 190 μ in Venetian turpentine and contains fifteen mature oospores. These have a smooth wall 43 μ in diameter and apparently about 2.5 μ thick. The inner boundary of the wall is not visible in this mounting medium. Within the wall the densely granular part of the protoplast is 29 μ in diameter and touches one side of the wall.

There are also present in the coenobium four empty capsules about 29 μ wide that are either the remains of abortive oogonidia or empty antheridia.

Specimen 52.—This specimen is selected from among a bewildering variety on the same slide because it exhibits characters of asexual and sexual coenobia in two daughters of the same age. It is in glycerine, and the material with it shows very little sign of shrinkage; the specimen in question, none at all. The mother is 350 μ wide and 320 μ long. The protoplasts range from about 4 μ at the back through 5 μ in the middle to about 6 μ at the front. The average spacing of the cells is about 7 μ, and the number of cells is about 7,500. The two daughters are 150 by 200 and 160 by 200 μ. The former contains two granddaughters, and the latter seventeen oogonidia and two androgonidia. The granddaughters are 70 by 88 μ and 70 by 90 μ, and each contains two gonidia of about 15 μ in diameter. The sexual daughter has the oogonidia about 12 to 15 μ wide, and the androgonidia, located on opposite sides of the middle, are smaller. One of these is undivided and about 8 μ wide. The other has formed a platelet of many sperms. This platelet is 7 μ thick and about 20 μ wide.

It is thought that the descriptions given will suffice for a fair picture of *Merrillosphaera africana* as it has been found at Manila. Extended search would undoubtedly reveal variations beyond the ranges of numbers and dimensions furnished by the material described. As an example, an exceptional coenobium was seen with three daughters and five bodies that had all the appearance of oogonidia. Another example is a very small coenobium, 126 by 152 μ, that contains five sperm platelets and seven oogonidia.

SUMMARY

The chief facts added to our knowledge of *Merrillosphaera africana* by the account of the typical form of the species as found at Manila are as follows:

1. The somatic protoplasts are not connected by protoplasmic filaments.

2. The gonidia are differentiated at a very early stage in the segmentation of the embryo.

3. The gonidia reach a considerable size before dividing; commonly about 55 μ, sometimes even 75 μ.

4. The gonidia form pairs whose members are about equal in size and are located symmetrically on opposite sides of the polar axis.

5. The largest, or only, pair of gonidia is about in the middle of the coenobium.

6. The additional gonidia are smaller and in the back of the coenobium.

7. When four gonidia are not present, absent pairs or members are commonly represented by abortive or vestigial gonidia.

8. When two pairs of gonidia are present there is sometimes a rudimentary third pair between the members of the first pair.

9. The sexual coenobia are of three kinds; bisexual, female, and male.

10. Asexual coenobia and sexual coenobia of the different kinds may be produced by the same mother in any combination.

11. In the bisexual coenobia the androgonidia are few and smaller than the oogonidia.

12. In the bisexual coenobia the androgonidia occupy positions like those of the gonidia in asexual coenobia; that is, two are on opposite sides of the middle of the coenobium and the third, with the fourth if there be one, is in the back part of the coenobium.

13. The androgonidia divide at about the time of birth of the coenobium and form platelets of sperms.

14. The female coenobia are like the bisexual, but without androgonidia.

15. The oogonidia are decidedly smaller than the gonidia.

16. The androgonidia are smaller than the oogonidia.

17. The male coenobia contain large numbers of androgonidia that divide at about the time of birth of the male coenobium or afterward.

18. The antheridia are platelets of sperms.

From the forms with six and those with eight gonidia the following points appear:

19. Forms occur with two pairs of gonidia that are nearly alike in size.

20. In forms with six gonidia the second pair is in the middle and its members alternate with those of the first pair.

21. In forms with eight gonidia the fourth and smallest pair is at the back and alternates with the third pair.

22. The bisexual coenobia sometimes have four antheridia distributed around the middle of the coenobium and one or more farther back.

23. The platelets of sperms sometimes take the form of shallow cups.

REVISED DIAGNOSIS OF THE SPECIES

In my first paper dealing with the genus *Merrillosphaera* there is given a diagnosis of *M. africana* drawn entirely from the accounts by West ('10 and '18) of the African material. Since the forms here described all seem to belong to the same species, the diagnosis of the species will be expanded to embrace them.

MERRILLOSPHAERA AFRICANA (West) Shaw.

Volvox africanus West in Journ. Quekett Micr. Club II 11 (1910) 102–103, *pl. 3, figs. 8–10*; II 13 (1918) 425–428, *pl. 29, figs. 4–6*.

Coenobia ovoid to ellipsoidal; ranging from 295 by 345 to 500 by 600 μ. Number of somatic cells between 3,000 and 8,000. Somatic protoplasts almost globose; 4 to 9.5 μ in diameter; widely separated in the front and grading to much closer at the back of the coenobium. Gonidia, 1 to 8; reaching 53 to 75 μ in diameter; in pairs of different sizes; the largest pair on opposite sides of the middle of the coenobium; other pairs successively smaller; the second of two pairs usually in the back of the coenobium; the second of three or four pairs usually in the middle of the coenobium between the first pair. Gonidia of daughters sometimes divide and produce granddaughters that are the beginning of the fourth generation while the daughters are still within the mother. Daughter coenobia strongly ovoid and more or less flattened by mutual pressure. Granddaughters at first spherical. Bisexual coenobia producing 2 to 6 antheridia with 12 to 43 oospores. Oogonidia more numerous and smaller than gonidia in sister coenobia. Oospores with thick smooth walls; diameter about 43 to 45 μ. Female coenobia like the bisexual. Male coenobia with between 100 and 400 antheridia; androgonidia smaller than oogonidia of same or sister coenobia; front of coenobium without reproductive cells. Antheridia in the form of platelets or shallow cups. Spermatozoids not described.

Habitat.—Albert Nyanza, Africa (*leg.* R. T. Leiper, 1907); Ussangu Desert, German East Africa (*leg.* A. W. Jakubski, 1909–10); fresh-water pools near Manila, Philippine Islands (*leg.* W. R. Shaw, 1914).[9]

[9] Slide mounts of material of this species from the vicinity of Manila have been sent to Prof. Douglas H. Campbell, Stanford University, California, and to Prof. Frank G. Haughwout, Bureau of Science, Manila, P. I. Material bottled in glycerine, has been sent to sixteen biologists in Europe and Asia and to sixteen in America. Duplicates of this bottled material are available for distribution from my United States address: Claremont, California.—W. R. S.

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ILLUSTRATIONS

[The figures on Plates 1 to 6 are photomicrographs of *Merrillosphaera africana* (West) Shaw and of new forms of the species, found at Manila, from specimens mounted in glycerine, unless otherwise noted, taken by W. R. Shaw and E. Cortes at the Bureau of Science, Manila. Those on Plate 7 are somewhat enlarged reproductions of the photomicrographs of African material that were made by G. S. West and used to illustrate his two papers in which this species was originally described.]

PLATE 1

FIG. 1. An asexual coenobium of the typical form of *Merrillosphaera africana*. This is the youngest coenobium represented on the plate. It measures 330 by 410 μ and contains one daughter with two gonidia (nonsexual reproductive cells). The gonidia are both about 30 μ wide. Specimen 1. $\times$ 100.

2. Another asexual coenobium of the same form. This is the most-nearly mature coenobium on this plate. It measures 460 by 520 μ and contains two daughters, each with one gonidium and one embryo. From left to right the third generation are: A gonidium of 53 μ; an 8-celled embryo of 54 μ; a gonidium of 53 μ; and a 2-celled embryo of 53 μ. Specimen 2. $\times$ 100.

3. A somewhat younger coenobium of the same form. It measures 430 by 540 μ and contains two asexual daughters, each with three gonidia. The four larger gonidia from left to right are 60, 57, 53, and 53 μ, and the two smaller ones are 46 and 42 μ. Specimen 3. $\times$ 100.

4. A coenobium of the same form that is the next to youngest on the plate. It measures 345 by 425 μ and contains two daughters, each with four gonidia. The larger gonidia, from left to right, are 38, 35, 38, and 40 μ, and the smaller ones 22, 20, 22, and 24 μ. Specimen 4. $\times$ 100.

5. A coenobium of the same form, measuring 365 by 450 μ, with two daughters that contain four and three gonidia. In the left daughter one gonidium of 33 μ width is mostly behind another of the same size, and the two small gonidia are about 20 μ wide. In the right daughter the larger gonidia are about 30 μ and the small one is about 20 μ wide. Specimen 5. $\times$ 100.

6. Another coenobium of the same form, measuring 450 by 540 μ, and having three daughters. The gonidia in the left daughter are about 50, 50, 30, and 30 μ; in the right daughter 48, 40, 32, and 32 μ; and in the hindmost 32, 30, and 18 μ. Specimen 6. $\times$ 100.

PLATE 2

FIG. 7. An asexual coenobium of the same form of *Merrillosphaera africana* as all of those on the preceding plate. It measures about 450 by 550 μ, but bulges greatly on account of pressure of the cover glass. It contains three offspring, one bisexual at the

left, one male at the right, and one asexual at the back. The bisexual daughter contains twenty-three oogonidia (female reproductive cells) of 25 to 29 μ in diameter and three androgonidia (cells that produce male elements) of about 18 μ width. The male offspring contains about one hundred fifteen androgonidia that are about 12 to 15 μ wide. Specimens 7, *7a*, and *7b*. × 100.

8. A male coenobium found associated with a different form of the species that is represented by Plate 2, fig. 13, Plate 3, fig. 14, and Plate 4, figs. 21 to 26, inclusive. It measures 270 by 350 μ and the androgonidia are numerous and about 10 μ wide. Specimen 24. × 100.
9. An asexual coenobium of the typical form. It measures 460 by 560 μ (bulging greatly on account of cover-glass pressure) and contains a bisexual and an asexual daughter. The bisexual daughter contains twenty-three oogonidia of 21 to 28 μ diameter and two androgonidia of 18 μ diameter. The latter are at the left and right sides of the daughter. The asexual daughter contains two embryos, one 8-celled and one 4-celled, that were formed from large gonidia, and one smaller gonidium of about 46 μ in diameter. Specimens 8 and *8a*. × 100.
10. A nearly mature sexual coenobium of the typical ovoid form. It measures 360 by 460 μ and contains twelve oospores that range from 39 to 43 μ wide. The spore walls are smooth and about 3 μ thick. Specimen 11. × 100.
11. An immature bisexual coenobium of the typical ovoid form. It measures 320 by 405 μ and contains twenty-nine oogonidia of about 30 μ in diameter and two androgonidia. One of the latter, in the right side of the coenobium and hidden by an oogonidium, is 19 μ wide. The other, at the left side above the middle, is divided into an immature platelet of thirty-two cells that measure 26 μ across. Specimen 10. × 100.
12. An asexual coenobium of the typical ovoid form. In its very bulging condition, due to cover-glass pressure, it measures 560 by 600 μ. It contains three sexual daughters in which female reproductive bodies preponderate. The left daughter contains twenty-eight oogonidia of 21 to 28 μ diameter, and two androgonidia, each about 18 μ wide. The right daughter contains fifteen oogonidia and two embryonic antheridia (sperm platelets or bundles of sperms) that are developing from androgonidia. One, at the left, is 4-celled, and the other, at the right, is 2-celled. The small daughter contains twenty-nine reproductive bodies 18 to 21 μ wide, among which no androgonidia are distinguishable. Specimens 9, *9a*, *9b*, and *9c*. × 100.
13. An immature asexual coenobium of the 6-gonidiate form that is shown in Plate 2, fig. 8, in Plate 3, fig. 14, and in Plate 4, figs. 21 to 26, inclusive. It is 290 by 325 μ in width and length, and contains two embryos and two gonidia. The embryos have the phialopores open. The gonidia are about 45 by 50 μ in diameter. Specimen 16. × 100.

PLATE 3

FIG. 14. An immature asexual coenobium of the same form of *Merrillosphaera africana* as those shown in Plate 2, figs. 8 and 13, and Plate 4, figs. 21 to 26, inclusive. It measures 370 by 390 μ and contains two advanced embryos with open phialopores, two very young embryos, and two gonidia. The young embryo that is the left member of the lower pair is 2-celled, that which is the right member of the upper pair is 4-celled. The gonidia measure about 50 by 52 μ and 50 by 55 μ, the inequality of the dimensions indicating preparation for division. Specimen 18. $\times$ 100.

15. A nearly mature sexual coenobium of the typically ovoid form. The dimensions are 500 by 585 μ, and the reproductive bodies are twenty-seven oospores. Specimen 12. $\times$ 100.

16. An oospore of the same coenobium, slightly out of focus, and the overlying somatic cells. The outside diameter of the spore is 40 μ. The diameters of the somatic protoplasts in sharpest focus are a little more and a little less than 5 μ. This spore is the one in the left side and nearest the front of the coenobium and is out of focus in the preceding figure. Specimen 12. $\times$ 400.

17. Another sexual coenobium of the same form. It measures 470 by 520 μ and contains thirty-one oospores that are not quite mature. A little above and to the left of the center an empty antheridial site may be seen. Specimen 13. $\times$ 100.

18. Four oospores from the same coenobium. The somewhat wavy appearance of their walls is due to shadows of overlying somatic cells. Diameters of spores about 41 μ. Specimen 13. $\times$ 400.

19. An asexual coenobium of a 6-gonidiate form, of which a younger one is shown in Plate 4, fig. 20. It was about 350 by 420 μ in breadth and length. The bulging of the sides is probably due to cover-glass pressure. The left daughter contains two granddaughters and four gonidia in pairs. The right daughter contains a granddaughter, an embryo, and two gonidia. In each daughter the nearest granddaughter contains four gonidia in pairs. Specimen 26. $\times$ 105.

PLATE 4

FIG. 20. A younger asexual coenobium of the same 6-gonidiate from of *Merrillosphaera africana* and from the same source as the one shown in Plate 3, fig. 19. It measures 230 by 290 μ and contains four daughters and one gonidium. Behind the right larger daughter there is a smaller one. The gonidium, 54 μ wide, is paired with the smallest daughter. The left daughter contains three gonidia. Specimen 25. $\times$ 105.

21. An asexual coenobium from the same source as the specimens shown in Plate 2, figs. 8 and 13, Plate 3, fig. 14, and Plate 4, figs. 21 to 26. It contains two daughters and two very young embryos. The daughters contain gonidia proportioned and arranged as were those of the mother. Specimen 17. $\times$ 100.

22. A sexual coenobium of the same form with about twenty-five oogonidia. Specimen 23. $\times$ 100.

23. A nearly mature asexual coenobium of the same 6-gonidiate form. The six daughters form three pairs of different sizes. The daughters all contain gonidia. Specimen 19. × 100.
24. An asexual coenobium of the same form containing four male coenobia that are nearly equal in size. Specimen 21. × 100.
25. The most-nearly mature asexual coenobium of this lot. It measures 470 by 570 μ. The left side is partly hidden by the shellac ring of the mount. Specimen 20. × 100.
26. An asexual coenobium of the same lot with four much-crowded sexual daughters, all apparently female, but possibly bisexual. Specimen 22. × 100.
27. A nearly globular asexual coenobium from another source. It contains two daughters that have the phialopores open, and three gonidia or young embryos. Specimen 37. × 100.
28. An asexual coenobium from the same source as the preceding. It contains four nearly equal daughters with the phialopores still open. Specimen 38. × 100.
29. A nearly globular asexual coenobium from the same source as those shown in Plate 5, figs. 31 to 34 and 36. It contains two daughters and one embryo. Each of the daughters contains four gonidia. Specimen 33. × 100.

PLATE 5

FIG. 30. An asexual coenobium of *Merrillosphaera africana* different in source from all the others. Each of the daughters contains four gonidia in pairs. Specimen 34. × 100.
31. An asexual coenobium of the 6-gonidiate form. It is 410 by 450 μ. The four larger daughters contain six gonidia each, and the two smaller ones four each. Specimen 27. × 99.
32. An asexual coenobium from the same source as that of the one shown in the preceding figure. The daughters each contain four gonidia. Specimen 28. × 100.
33. An asexual coenobium from the same source as the preceding. Specimen 30. × 100.
34. Another asexual coenobium from the same source. Specimen 31. × 100.
35. A young coenobium from the same source as that shown in fig. 38. It contains three embryos. Specimen 36. × 100.
36. An asexual coenobium with four daughters of nearly equal size. This is from the same source as those of figs. 29, and 31 to 34. Specimen 32. × 100.
37. An asexual coenobium from the same source as those of figs. 29, 31 to 34, and 36. It contains two asexual and two sexual daughters. The asexual daughters contain four and three embryos in 2- to 8-celled stages. The sexual daughters contain eighteen and twenty-three reproductive bodies. Specimen 29. × 100.
38. An asexual coenobium from the same source as that of fig. 35. The daughters all contain gonidia. Specimen 35. × 100.

PLATE 6

FIG. 39. An asexual coenobium of an 8-gonidiate form of *Merrillosphaera africana,* as are those of the three following figures. These are all mounted in Venetian turpentine. This coenobium contains six daughters, and in all of them the only developing reproductive bodies are two gonidia that are in different daughters. Specimen 39. × 100.

40. An asexual coenobium of the same form as that of the preceding figure. It contains six daughters in pairs, and an odd young embryo. The daughters contain only gonidia. Those in the larger daughters are 53 to 58 μ wide. Specimen 40. × 100.

41. An asexual coenobium of the same form as that of the two preceding figures. It contains six daughters and two embryos of about one hundred sixteen cells each. In the largest daughters there are six and five gonidia; in each of the others four. Specimen 41. × 100.

42. An asexual coenobium of the same form as that of the four preceding figures. It contains six daughters. One large daughter contains six, the other large one and a smaller one each five, and the other smaller daughters each four gonidia. Specimen 42. × 100.

43. A sexual coenobium of a small form of the species in Venetian turpentine. It is from the same source as those of the two following figures, and they are all mounted in the same medium. It contains about twenty oospores of 35 to 39 μ diameter. Specimen 43. × 100.

44. An asexual coenobium from the same source as that of the preceding and following figures. It is considerably shrunken by the process of mounting in Venetian turpentine. It contains two daughters, each with two gonidia. Specimen 44. × 100.

45. Another asexual coenobium from the same lot. It contains two daughters, each with two robust and one or two vestigial gonidia. Specimen 45. × 100.

46. An immature bisexual coenobium of the typical 4-gonidiate ovoid form of the species shown by Plate 1 and Plate 2, figs. 7 and 9 to 12, inclusive. It measures 410 by 515 μ. The reproductive bodies are thirty-two oogonidia about 37 μ in diameter and an antheridium, a little to the left of and above the center, consisting of a sperm platelet. Specimen 14. × 100.

47. The most mature of all the bisexual coenobia that are figured in these plates. It measures in the picture 515 by 620 μ. It is greatly compressed under the cover glass, and its dimensions before compression were probably nearer 500 by 600 μ. In it there are twenty-seven oospores. They have smooth walls about 43 μ in outside diameter and 37 μ in inside diameter. There are three antheridial sites; two at the middle level on opposite sides of the coenobium, and another in the back part of the coenobium. Specimen 15. × 100.

PLATE 7

[All of the figures on this plate are reproductions, somewhat enlarged, of photomicrographs that were made by the late Prof. George Stephen West, of the botanical department of the University of Birmingham, and used to illustrate his two papers in which this species was originally described from African material.]

FIG. 48. An asexual coenobium of *Merrillosphaera africana* from Albert Nyanza, Africa. It measures 475 by 595 μ and contains three daughters with three, four, and four granddaughters or embryos, respectively. In the larger granddaughters gonidia are visible. × 100.

49. An asexual coenobium from the same source, measuring 455 by 525 μ, and containing three daughters with three, two, and two granddaughters or embryos, respectively. × 83.

50. Another asexual coenobium from the same source, measuring 420 by 490 μ and containing four daughters, each with four gonidia or embryos. × 83.

51. A sexual coenobium from the Ussangu Desert, in what was formerly German East Africa. It measures 565 by 660 μ and contains about thirty-nine oospores. The most distinctly visible spore wall measures, according to the magnification stated, about 51 μ. × 88.

52. Another sexual coenobium from the same source, measuring 600 by 780 μ, and containing about forty-one oospores. × 88.

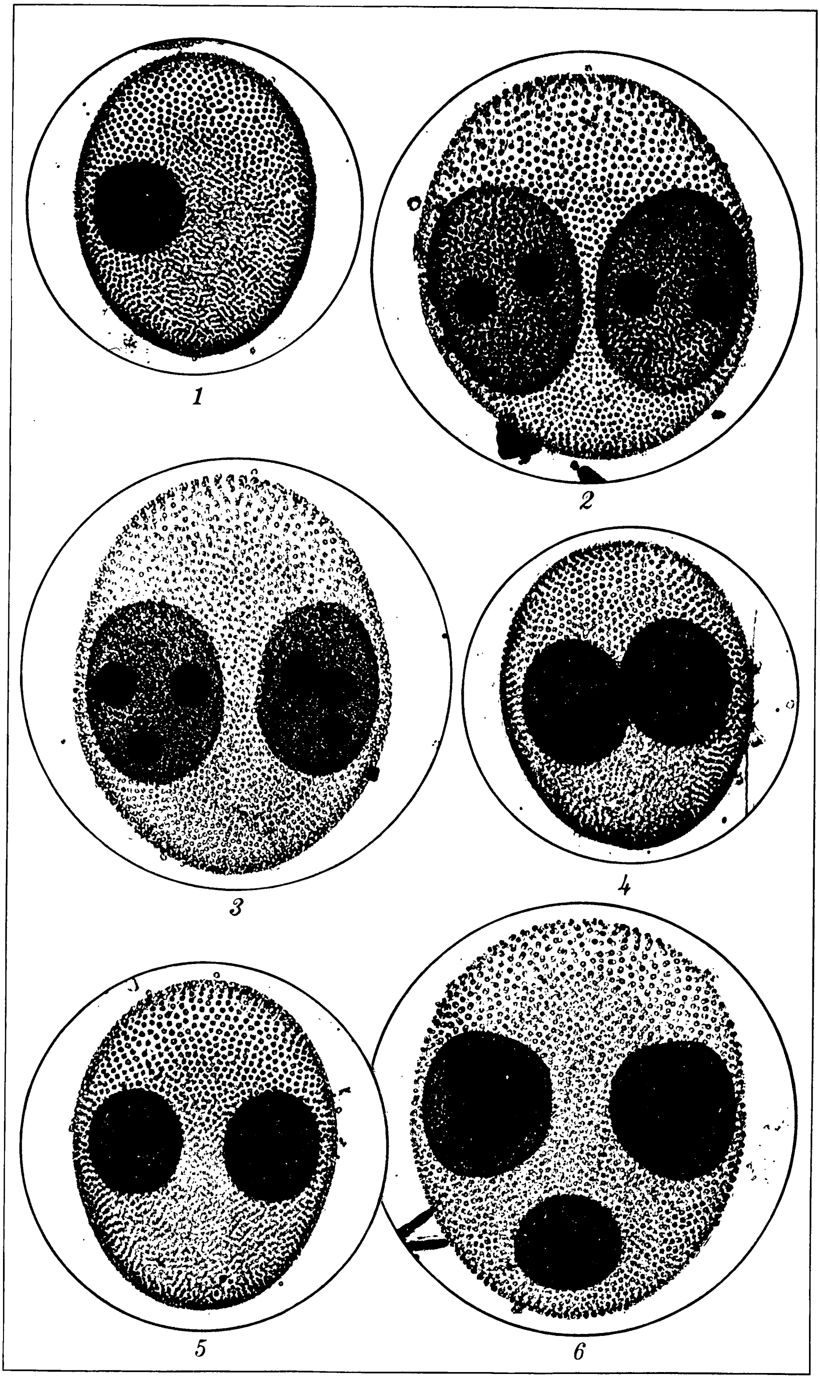

PLATE 1. MERRILLOSPHAERA AFRICANA (WEST) SHAW.

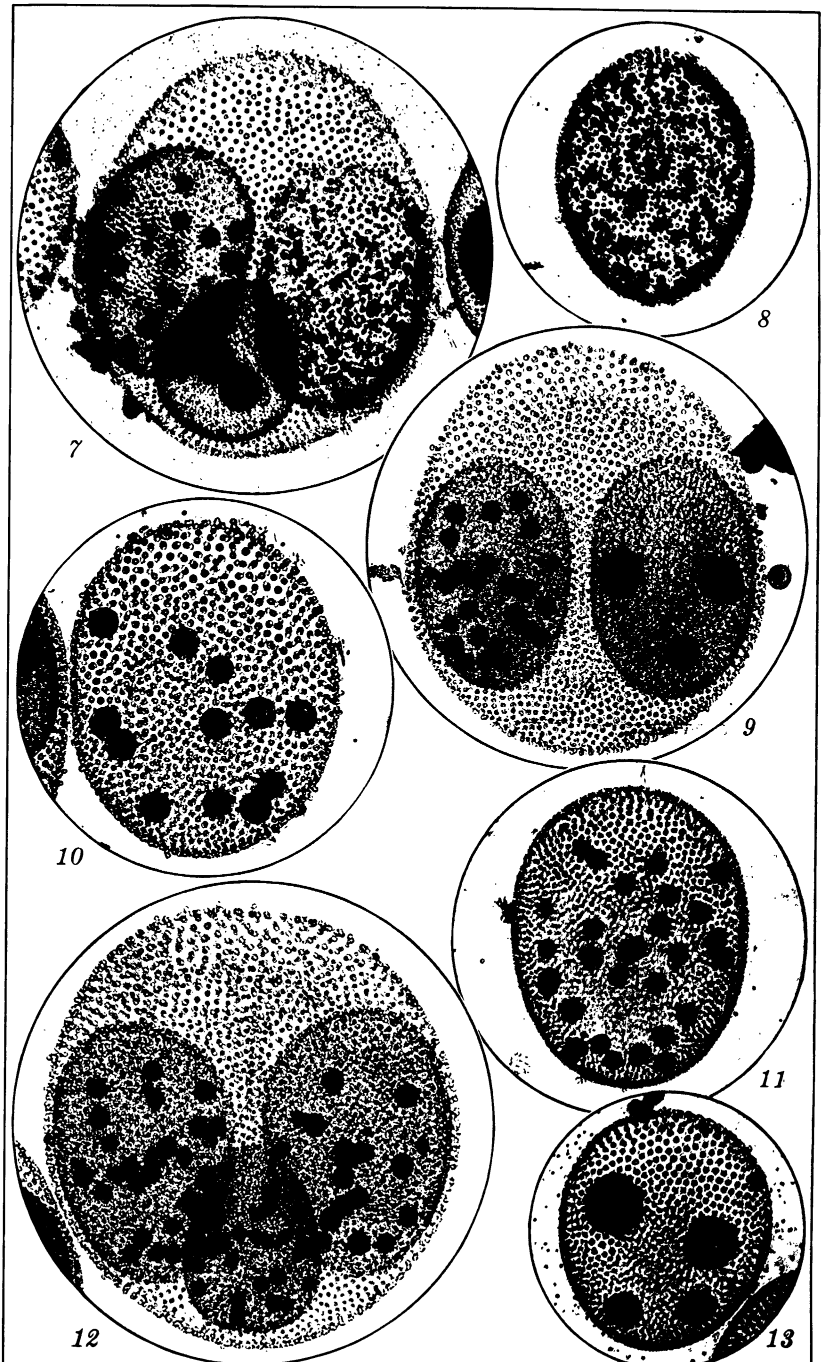

PLATE 2. MERRILLOSPHAERA AFRICANA AND RELATED FORM.

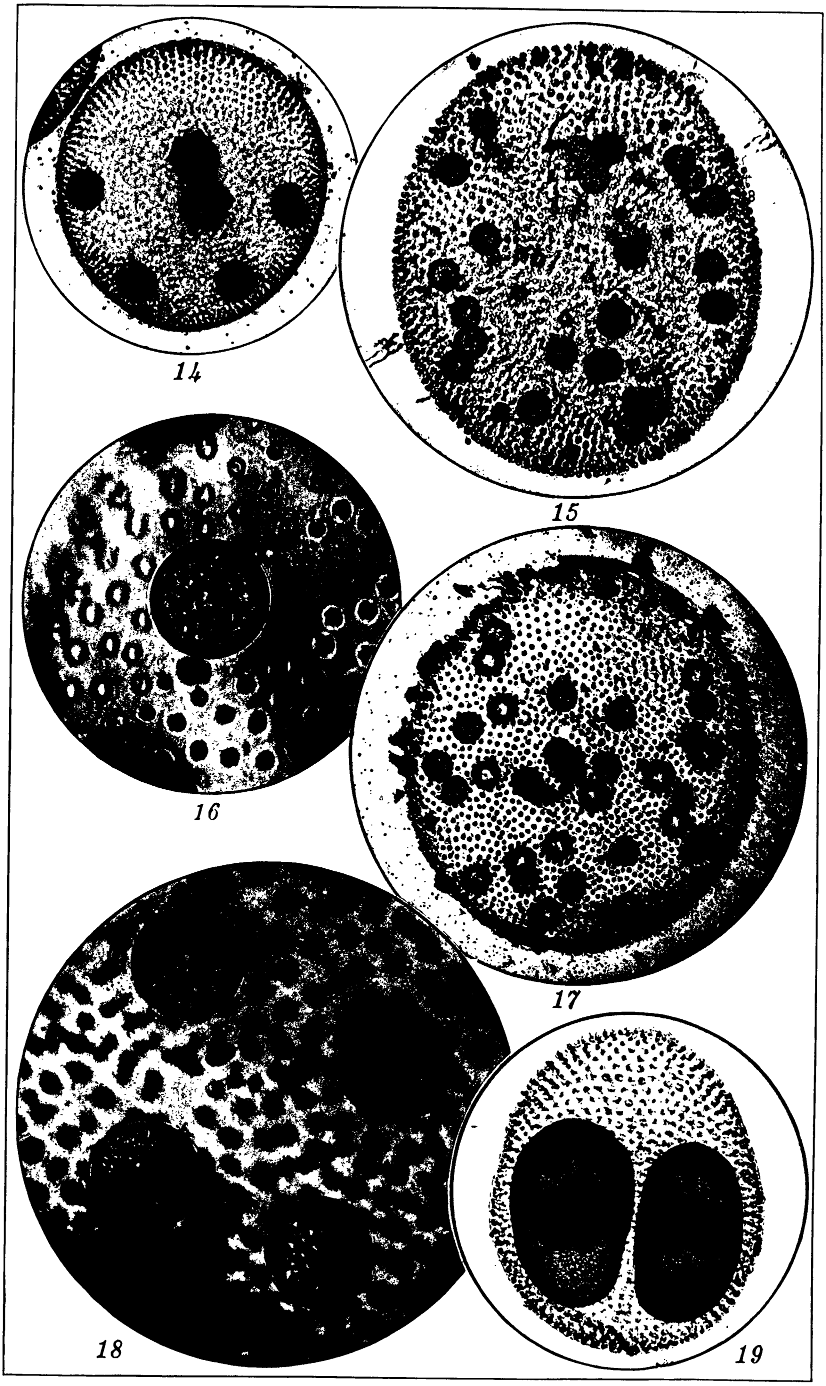

PLATE 3. MERRILLOSPHAERA AFRICANA AND RELATED FORM.

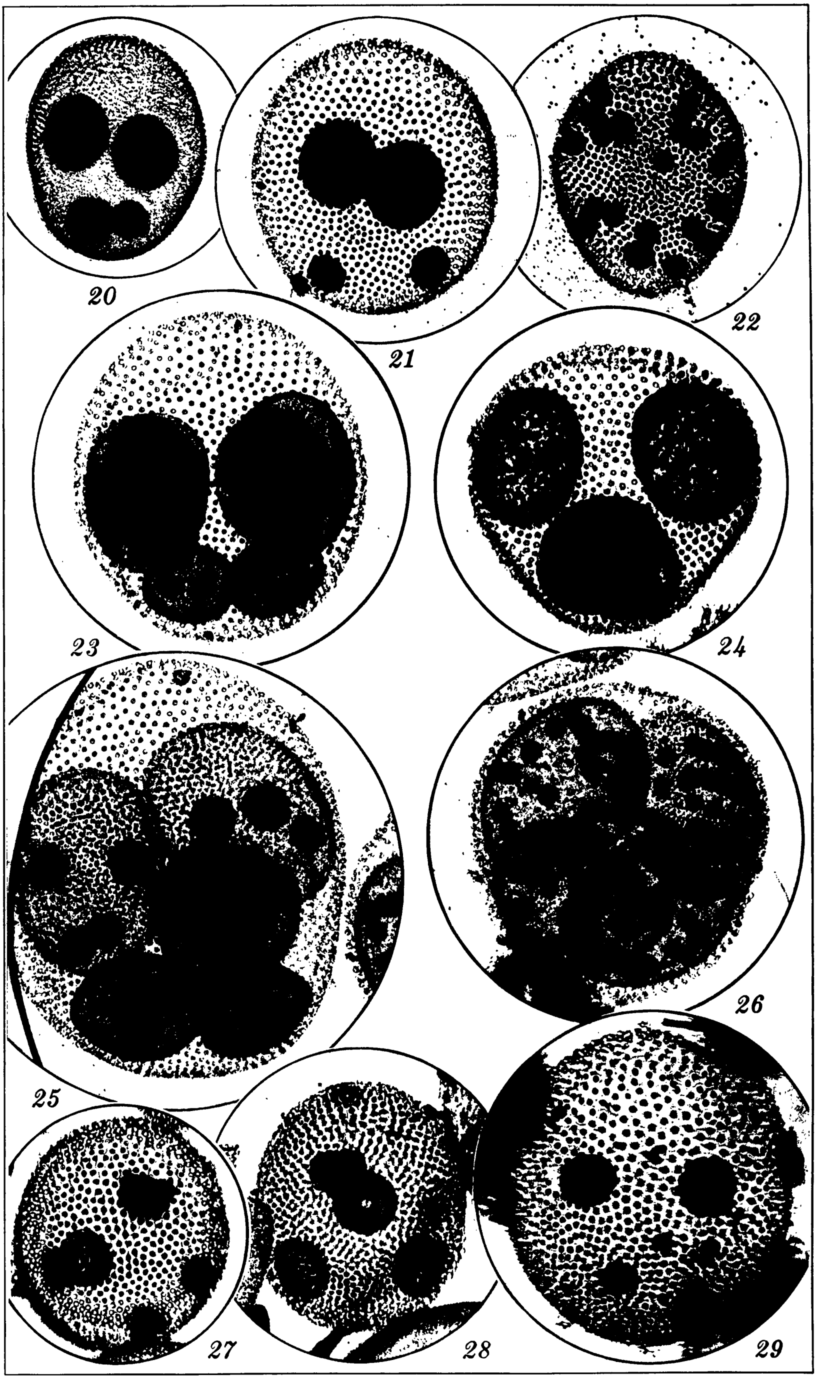

PLATE 4. MERRILLOSPHAERA.

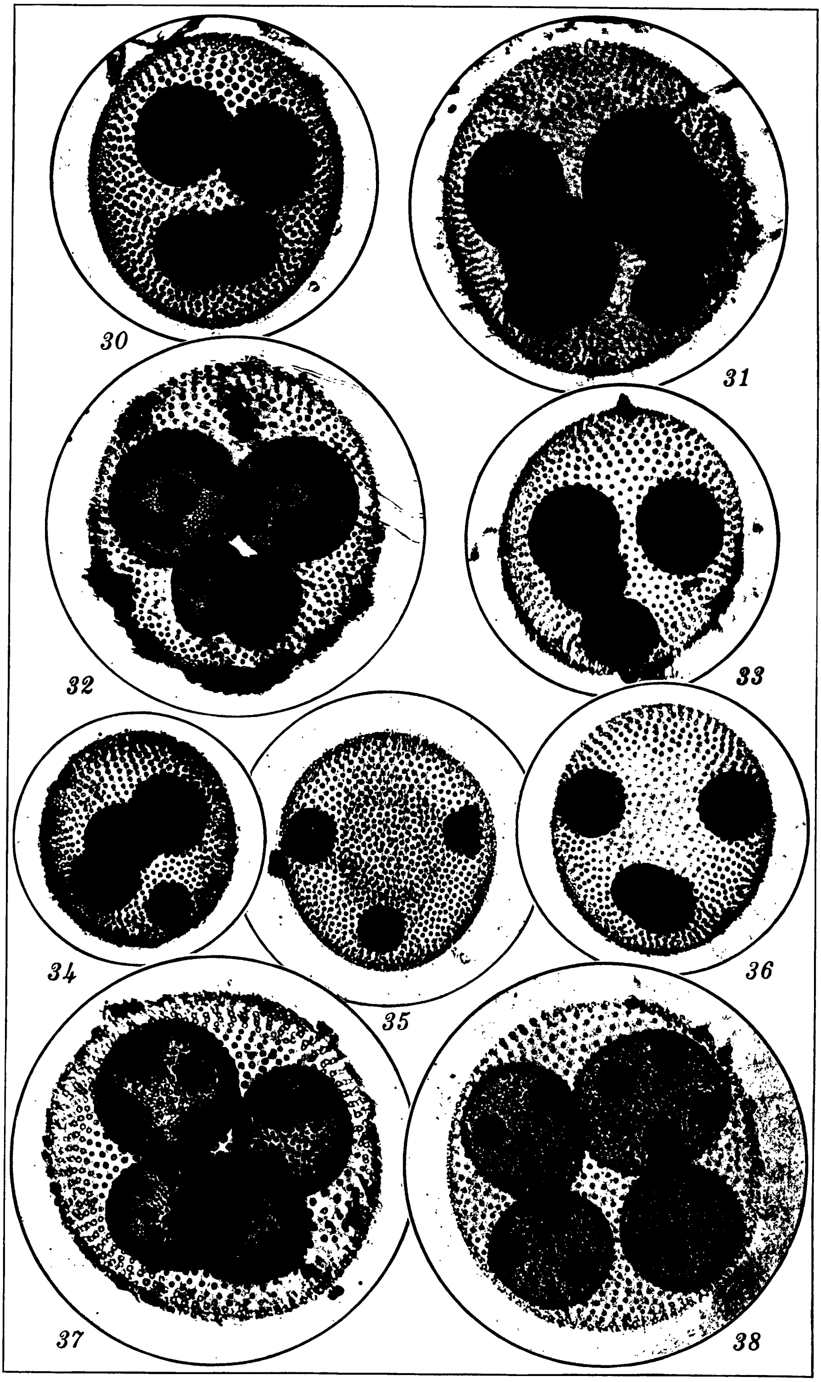

PLATE 5. MERRILLOSPHAERA.

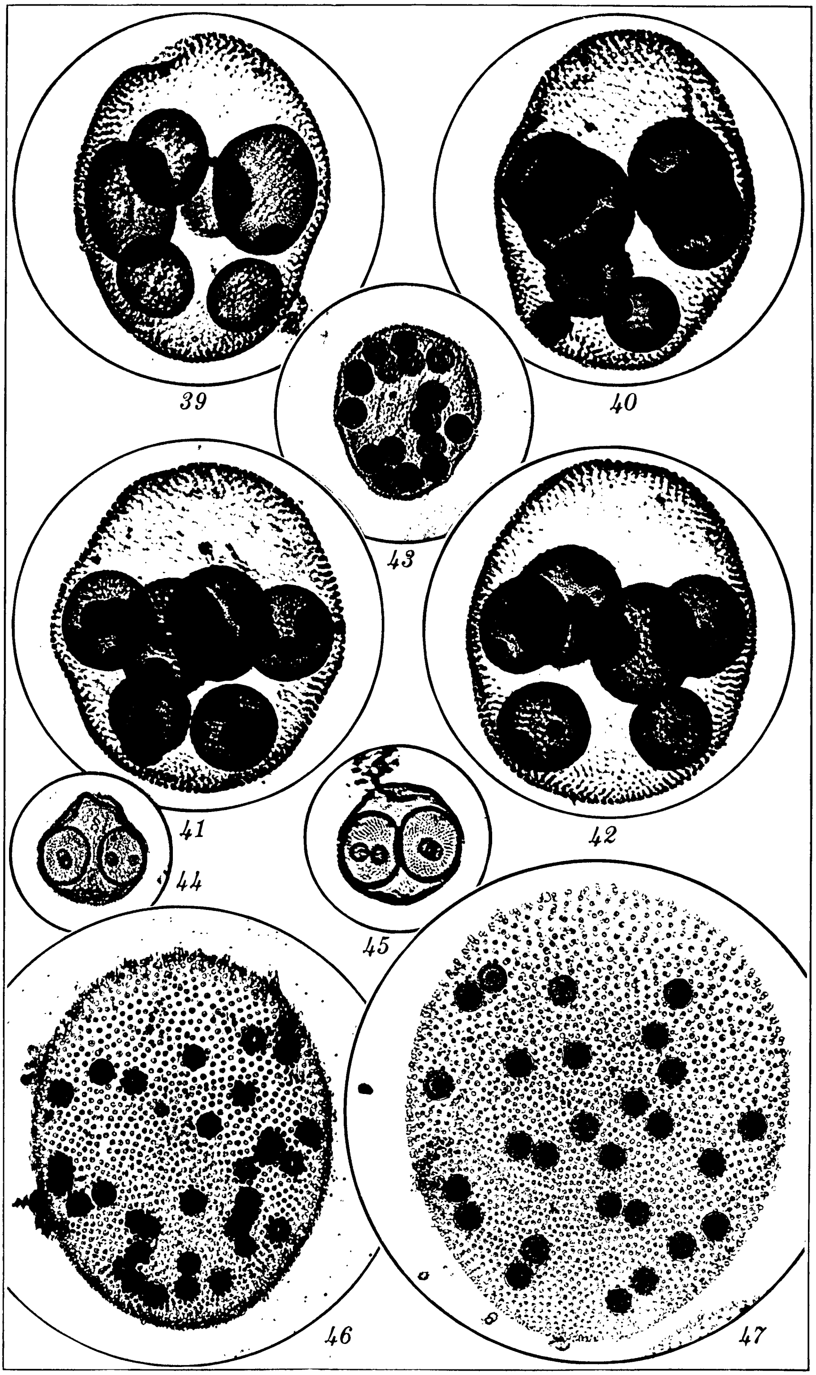

PLATE 6. MERRILLOSPHAERA AFRICANA AND RELATED FORM.

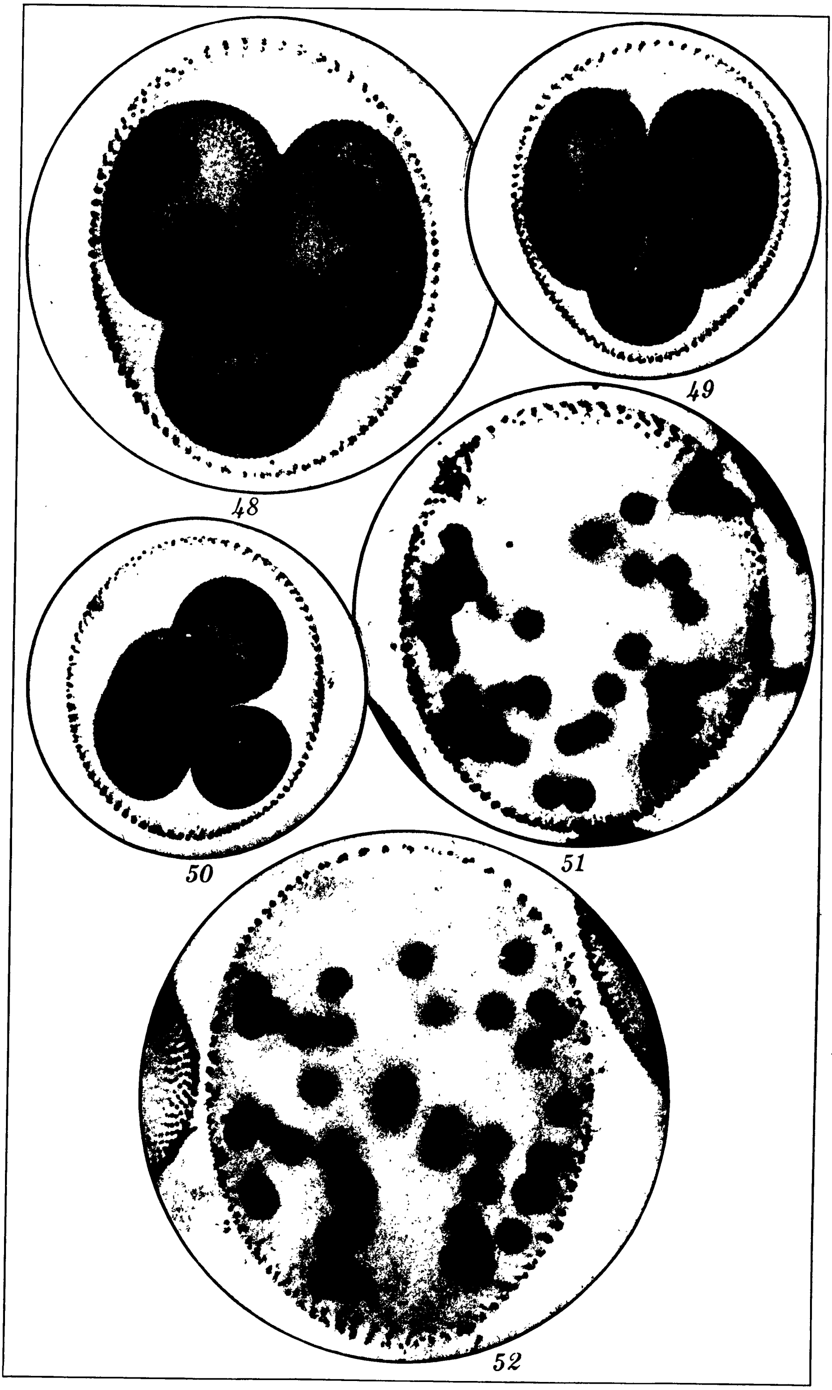

PLATE 7. MERRILLOSPHAERA AFRICANA (WEST) SHAW.

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THE PHILIPPINE
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INVESTIGATIONS CONCERNING YAWS

By ANDREW WATSON SELLARDS
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and
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The following studies of yaws, of which this paper is the first, are based upon experience in the treatment of the disease in the Dominican Republic in the West Indies and upon investigations conducted at Parañaque and Las Piñas in the suburbs of Manila, Philippine Islands.

In the Dominican Republic, the major portion of the work was conducted in a field camp in a rather isolated section, inhabited for the most part by a somewhat primitive people. During the summer of 1920, in the course of two months, approximately three hundred fifty cases of yaws in the granulomatous stage were treated intravenously with neosalvarsan; these cases as well as those received in the later stages have already been reported.(2) Toward the close of the summer, the work was extended to another district of Santo Domingo in which two hundred active cases of yaws were treated by intramuscular injection of neosalvarsan.

The successful utilization of neosalvarsan under strictly field conditions in Santo Domingo raised the question of the feasibility of controlling or even eradicating yaws by treatment of infected individuals. In order to carry out field work intelligently, it seemed clear that certain preliminary investigations were

essential. Accordingly the study of yaws was continued, with the object of giving special attention to the features bearing upon the problem of its control by public-health measures. Through the courtesy of the Philippine Health Service a temporary dispensary was opened at Parañaque, near Manila, a district the inhabitants of which have been from time immemorial constantly infected with yaws. The patients were under the immediate care of Dr. Perpetuo Gutierrez, and the observations of clinical interest have been described by him.(1)

There are several attractive problems in the immunology of yaws. The behavior of the Wassermann reaction has not been thoroughly investigated; it is a subject of considerable interest, both from a serological point of view and on account of its practical importance. The reinoculation of yaws patients with the virus of yaws requires further investigation. From the standpoint of both the individual and the public it is very important to know whether spontaneous infection that has been cured by salvarsan affords any protection against reinfection. The investigation of the Wassermann reaction and the behavior of yaws patients upon reinoculation with yaws form the basis of the second and third papers of this series.

From the standpoint of field work, the choice of treatment and the method of administering salvarsan assume aspects which are very different from the conditions that obtain in standard hospital practice. This subject, together with other features of yaws that are of interest in the field of public health, will be considered in the fourth paper of this series.

The fifth paper deals with some problems in the histology of yaws which have been cleared up by Doctor Goodpasture during these investigations.

In the last paper of this series a brief discussion is presented concerning the possible control or even the eradication of yaws.

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THE EFFECT OF TREATMENT ON THE WASSERMANN REACTION IN YAWS

By Ernest W. Goodpasture and Walfrido de Leon

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At the yaws clinic established in Parañaque, near Manila, the Wassermann reaction was performed with sera, obtained before treatment, from 45 patients presenting active cutaneous lesions of this disease. Complete fixation of complement occurred in each instance, or in 100 per cent.

This result is in accord with the experience of many previous workers. Baermann and Wetter(1) tested the serum of 38 untreated cases of yaws rich in lesions and found 100 per cent positive. Schüffner(7) also reported 100 per cent positive in 38 similar cases.

Recently Moss and Bigelow(6) recorded briefly the results of the Wassermann test in 91 cases, at Santo Domingo. They found reaction strongly positive in 78 cases, moderately positive in 4, weakly in 1, and negative in 8. The negative results were obtained only in the late secondary and tertiary stages, or in patients who had no active lesions but who gave a history of yaws. These investigators subsequently also found 100 per cent positive reactions in the early stage of the disease.

From such reports it is evident that one may expect to find in the early eruptive stage of yaws, as in the florid secondary stage of syphilis,(5) a positive Wassermann reaction in 100 per cent of cases; consequently, the test offers no aid in differential diagnosis of the two diseases.

However, the constancy of positive reaction in the early stage of yaws suggests that the test should throw some light on the extent of treatment necessary, as it has done in syphilis. This phase of the subject has received scarcely any attention, although it is obviously of utmost importance, because efforts to eradicate the disease would necessitate treating hundreds of patients in endemic foci usually under field conditions where adequate observation over long periods of time would be next to im-

possible. The public-health officer under these circumstances is confronted with the question whether treatment may be discontinued, when a clinical cure is effected, without danger of an undue percentage of recurrences, and it may be properly asked whether the Wassermann test can be of any service in reaching an answer to this question.

With such problems in mind several cases in the acute secondary stage of yaws were investigated with reference to the complement-binding strength of titrated sera by means of the Wassermann reaction before treatment and clinical cure, and at intervals afterward, and where possible until they became negative.

Only one satisfactory observation bearing on the duration of the Wassermann reaction after treatment was found; namely, the single case, reported by Shamberg and Klauder,(8) of an American soldier who contracted the disease in France. The test was frequently repeated over a period of six months, during which time the patient received three intravenous injections of neosalvarsan, 0.9 gram each. At the end of two months the reaction had begun to weaken, and after six months was negative with alcoholic extract of syphilitic liver, acetone insoluble antigen, and almost so with cholesterized antigen. No one apparently has measured the complement-binding strength of titrated sera from yaws patients either before or after treatment.

Twenty-three young Filipinos, all presenting fresh cutaneous yaws, were selected for study. On twelve of these it has been possible to repeat the Wassermann test at intervals over a period of several months.

METHOD

The Wassermann test was performed according to the details described by Hinton.(4) In the hæmolytic system two units of antisheep amboceptor, 0.5 cubic centimeter of a 5 per cent suspension of washed sheep-cells brought to the original volume of whole blood, and two units of guinea-pig serum complement were used in each test. The uniformity of sheep-cell suspension was controlled by a color standard, and sera from several pigs were pooled to obtain a complement of uniform strength. A maximum of 0.1 cubic centimeter of patient's heated serum was used in each test and a control of 0.2 cubic centimeter, for anticomplementary action. Only one antigen was employed, instead of three as practiced by Hinton. Most of the tests were made with cholesterinized alcoholic extract of guinea-pig's heart used in

doses of 0.1 cubic centimeter of a 1 plus 4 dilution. This antigen was not anticomplementary with twice the amount used in the test. A few tests were made with a cholesterinized alcoholic extract of beef heart in doses of 0.2 cubic centimeter of a 1 plus 4 dilution of approximately the same antigenic strength as the former antigen, and showing no inhibition of hæmolysis with twice the amount used in each test. The test was controlled by the use of normal and syphilitic sera.

The results of tests on the twenty-three sera [1] titrated before treatment to determine the minimal fixing dose—that is, the least amount of serum necessary to prevent complete hæmolysis—are tabulated in Table 1.

TABLE 1.—*Wassermann reaction with titrated serum from yaws.*

	Cases of active yaws.	Minimal fixing dose of serum. cc.
	[a] 1	0.1
	4	0.01
	6	0.005
	4	0.004
	5	0.003
	3	0.002
	0	0.001
Total	23	

[a] This case gave a 3 + reaction.

It is to be observed that approximately half of these sera have a minimal fixing dose of 0.004 cubic centimeter or less, and in only one is 0.1 cubic centimeter necessary for a positive reaction. The serum of a yaws patient in this stage of the disease is evidently strong in its complement-binding power with lipoidal antigens, and in this respect compares favorably with sera from untreated syphilis. Serum from three untreated cases of syphilis was titrated for comparison, the minimal fixing dose being 0.002, 0.1, and 0.01 cubic centimeter, respectively.

So far as the results go, it can safely be said that the maximum complement-binding strength of serum from early secondary yaws is equal in the Wassermann test to the maximum found in syphilis.

Twelve of the twenty-three cases of yaws were observed over a period of several months. The Wassermann reaction was

[1] In two of these cases Wassermann reaction was performed on spinal fluid and found negative.

performed and the minimal fixing dose of serum established a second time, shortly after clinical cure, and again some months later when several of them had become negative. Table 2 gives a summary of these cases and the clinical results of treatment.

In Table 3 are tabulated the results of the test before treatment on these twelve cases and the effect of treatment on the complement-binding strength at intervals afterward.

It is evident from Table 3 that, during the first month after treatment, there is a rapid fall in complement-binding strength with lipoidal antigen, then a more-gradual weakening over a period of several months until in the majority of cases the reaction becomes negative with 0.1 cubic centimeter, or the standard dose of serum. Several of these cases received a second injection of neosalvarsan but always in about two weeks after the first, so that the initial rapid diminution in strength of the serum in the first month may have been due to the repeated treatment. Nevertheless, the Wassermann reaction with 0.1 cubic centimeter of serum was still strongly positive a month or more after the first injection, and two or three weeks after clinical cure in several instances, and in seven of the twelve cases was still positive five months after the first injection. The fact is established that clinical cure is not coincident with disappearance of positive reaction; but, in our studies, the serum gradually, within a period of several months, became negative in seven of the twelve cases and much weaker in the others, following clinical cure and without further treatment.

The rapidity with which a positive serum becomes negative in a general way seems to depend on the degree of complement-fixing strength with lipoidal antigens present in a particular serum before treatment, although there are exceptions to this even in our small series. If we compare the six weakest sera with the six strongest we find an average minimal fixing dose for the former of 0.0071 cubic centimeter, and for the latter 0.0026. One month after treatment the corresponding figures are 0.053 and 0.023. In five months we find in the first group three negative sera and three weakly fixing sera, and in the second group two negative, two strongly positive, and two weakly fixing.

We judge from this behavior of the Wassermann reaction that a positive test following clinical cure does not necessarily indicate persistence of the infection, but may rather be due to a gradual process of elimination by the body of substances upon which a positive reaction depends; and, since the majority of

TABLE 2.—*Treatment of twelve cases of yaws with neosalvarsan.*

Case.	Sex.	Age.	Duration of yaws.		Present lesions.		Treatment.						
					Mother yaw.	Secondary lesions.	First injection.		Result.	Second injection.		Result.
		Yrs.	*Yrs.*	*mos.*				*g.*			*g.*	
1	M	7	1	0	None	Hands, head, back, and left foot.	September 12, 1921	0.45	September 21, 1921, healing.	September 21, 1921	0.45	February 17, 1922, cured.
2	F	5	1	0	(?)	Face, body	do	0.3		September 27, 1921	0.3	October 31, 1921, cured.
3	F	12	0	3	Left arm	Face, neck, axilla	September 19, 1921	0.45	September 29, 1921. Secondaries dry; primary not healed.	October 3, 1921	0.45	October 3, 1921, almost cured.
4	F	18	0	9	None	Face, body	September 12, 1921	0.6	September 21, 1921, lesions dry.	September 29, 1921	0.6	October 29, 1921, cured.
5	F	11	2	0	do	Mouth, thigh, bones of fingers, and feet.	do	0.45	September 21, 1921, skin lesions dry.	October 27, 1921	0.3	Skin lesions cured.
6	F	12	1	0	do	Face, thigh, perineum.	September 19, 1921	0.3	October 3, 1921, skin lesions dry.	October 3, 1921	0.45	October 27, 1921, cured.
7	M	7	2	0	do	Head, body	September 22, 1921	0.45	October 3, 1921, cured.	do	0.3	
8	F	14	0	9	Knee	Head, back, axilla, legs.	September 19, 1921	0.6	do	do	0.6	
9	M	3	0	3	Forehead	Face, body, legs	do	0.3	October 3, 1921, almost cured.	do	0.3	October 27, 1921, cured.
10	M	7	2	0	None	Face, perineum, legs.	September 12, 1921	0.3	September 29, 1921, cured.			
11	M	14	10 (?)	0	do	Face, body	do	0.45	September 29, 1921, nearly cured.	September 27, 1921	0.45	October 12, 1921, cured.
12	M	11	1	0	do	Perineum	do	0.45	September 29, 1921, lesions dry.	October 3, 1921	0.45	Cured.

TABLE 3.—*The Wassermann reaction with titrated yaws serum before and at intervals after treatment with neosalvarsan.*

Case No.	Before treatment.							After first injection.					Days.	Serum in cubic centimeters.			Days.	Serum in cubic centimeters.		Days.
	Serum dilutions in cubic centimeters.							Serum in cubic centimeters.												
	0.1	0.01	0.005	0.004	0.003	0.002	0.001	0.1	0.01	0.005	0.004	0.003		0.1	0.01	0.005		0.1	0.01	
1	4	4	3	2	1	0	0	4	1	0	0	0	42	0	0	0	158	......	......	......
2	4	4	4	4	3	2	0	4	1	0	0	0	49	1	0	0	158	0	0	246
3	4	3	0	0	0	0	0	3	0	0	0	0	35	0	0	0	151	......	......	......
4	4	4	3	2	1	0	0	4	0	0	0	0	49	0	0	0	158	......	......	......
5	4	4	3	2	0	0	0	4	3	0	0	0	45	3	0	0	171	0	0	246
6	4	4	4	4	4	3	0	4	3	2	1	0	24	4	0	0	164	2	0	239
7	4	3	1	0	0	0	0	4	0	0	0	0	21	0	0	0	161	......	......	......
8	4	4	4	4	4	3	0	4	4	4	3	0	24	4	0	0	164	......	......	......
9	4	2	0	0	0	0	0	4	0	0	0	0	24	0	0	0	164	......	......	......
10	4	4	3	1	0	0	0	4	4	2	1	0	35	3	2	0	171	4	0	246
11	4	2	0	0	0	0	0	4	2	0	0	0	35	2	0	0	171	2	0	246
12	4	4	3	1	0	0	0	4	4	4	3	0	31	2	0	0	178	2	0	253

[4 = no hæmolysis, 3 = faintest hæmolysis, 2 = strong hæmolysis, 1 = almost complete hæmolysis, 0 = complete hæmolysis. The time each test was performed is recorded in the number of days after the first injection of neosalvarsan.]

sera will spontaneously become negative in the course of a few months, it is not necessary in treating the disease on a large scale to continue therapy until a negative reaction is accomplished. A better guide would seem to be the complete healing of all clinical manifestation of activity of the disease.

Bearing upon this point and supporting the above conclusion is the reported alteration of the Wassermann reaction following treatment of yaws with mercury.

Baermann and Wetter state that the reaction became negative in about 50 per cent of cases of yaws following a single course of treatment with mercury. In contrast to syphilis they noted frequently a diminution in strength of the reaction or a complete alteration after even two or three injections of the salicylate. The reaction in their experience seemed to remain negative in yaws after treatment longer than in syphilis. Although these authors do not state the exact time in which a reversal in reaction took place they probably mean within a few weeks. This is not the case following injections of neosalvarsan, although this drug is incomparably more effective than mercury in the treatment of yaws. Evidently no great clinical importance can be attached to reported changes in the Wassermann reaction following mercury therapy.

In order to observe the effect of mercury on the cutaneous lesions of yaws and on the Wassermann reaction we made observations on four acute cases, all of whom were Filipinos of about the same age, with abundant fresh secondary lesions. The following protocol of one of these cases will serve to illustrate this group. The treatment given each of these cases was the same and in each case it proved equally ineffective.

The patient was admitted to the Philippine General Hospital with early secondary lesions of yaws. He received three intramuscular injections of 0.25 cubic centimeter succinamide of mercury (1 per cent) at four-day intervals, four 0.5 cubic centimeter injections at three-day intervals, two 1 cubic centimeter injections at two-day intervals, and two 0.5 cubic centimeter injections of mercury salicylate with an interval of seven days between doses. The period of treatment was from September 24 to October 31. There was no noticeable effect on the skin lesions and 0.45 gram of neosalvarsan was given intravenously and was followed by immediate healing.

Table 4 presents the results of Wassermann tests performed before treatment, and twice during treatment.

While a moderate initial diminution in complement-fixing strength is evident in Table 4, after five weeks of treatment no

further weakening is noted, and clinically, notwithstanding the diminished fixing strength of serum, the lesions continued active throughout the period of treatment. Following a single injection of neosalvarsan the lesions rapidly healed.

TABLE 4.—*Wassermann reaction in cases of yaws treated with mercury.*

Case No.	Serum titration in cubic centimeters.													
	September 22, before treatment.						October 13.				October 31.			
	0.1	0.01	0.005	0.004	0.003	0.002	0.1	0.01	0.005	0.004	0.1	0.01	0.005	0.004
1	4	4	3	2	1	0	4	3	0	0	4	3	0	0
2	4	3	1	0	0	0	4	0	0	0	4	0	0	0
3	4	3	2	1	0	0	4	1	0	0	-----	-----	-----	-----
4	4	4	3	3	1	0	4	3	1	0	4	4	1	0

After intravenous injection of neosalvarsan a preliminary relatively rapid drop in the fixing strength of serum was also noted and, in order to determine whether the immediate presence of the drug in the serum was partially responsible for this, the serum of a single case was titrated before and immediately after intravenous injection. The results of the Wassermann reaction with the two samples were identical.

The supposition seems justifiable that the gradual diminution in complement-fixing strength of serum over a period of several months following an initial effective treatment, with an eventual return to a negative reaction, indicates that the patient has been completely cured. In syphilis the Wassermann reaction may readily become negative during treatment only to return when treatment is discontinued. Should any infection remain we might expect persistence of positive reaction if not increase in fixing strength of the serum. There is evidence, presented by a large proportion of latent or chronic cases of yaws, that a positive reaction may be present years after the acute manifestations of the disease have subsided. Schüffner reports 85 per cent positive in chronic late yaws and 58 per cent in the latent type. We tested the serum of six adults who presented no obvious evidences of the disease but gave a history of yaws in childhood, and found two, or 33 per cent, positive.

Since the Wassermann reaction has become negative in the course of five or six months after treatment in the majority of cases, the indications are that, in the event that reaction continues positive for a year or more, the treatment has been insufficient and should be repeated even though no recurrence be evident. Provided treatment at first is continued until there is a complete healing of superficial lesions the number of such cases probably would be exceedingly small.

At the clinic in Parañaque several children with chronic indolent ulcers, especially of the feet and ankles, presented themselves for treatment, some of them giving a history of yaws in the past. Sera from six such individuals in whom the diagnosis of yaws was questionable, though four gave a history of yaws, were strongly positive. No doubt many ulcers of this kind are based upon an original infection with *Treponema pertenue* and, in an attempted eradication of the disease from an endemic focus, they are an important factor.

Castellani (3) was able to demonstrate specific fixation of complement with an antigen prepared from yaws papules containing *Treponema pertenue* and serum from a monkey that had been successfully inoculated with yaws and afterwards treated at intervals with subcutaneous inoculations of yaws material. This fact encouraged the hope that by this means, using serum from patients, yaws and syphilis might be differentiated. Bowman (2) later reported positive fixation with such antigen and sera from yaws patients, and negative tests with sera from syphilitics, but the tabulation of his results indicates that the reaction was not entirely specific. We repeated the test with an antigen prepared from an early yaw containing treponemata, according to the method used by Bowman, using otherwise the technic employed for the Wassermann reaction. Two syphilitic sera and two yaws sera, each strongly positive with cholesterinized antigen, and two normal sera showed no fixation of complement. In view of the close similarity of the Wassermann reaction in the two diseases, it seems extremely doubtful that an antigen will ever be prepared sufficiently specific for practical purposes in differentiating yaws and syphilis.

DISCUSSION

A positive Wassermann reaction in the Tropics does not bear the same diagnostic significance that it does in the Temperate Zone. It is present in a large proportion of cases of leprosy free

of syphilis, and has been frequently reported in malaria, but its constancy in yaws is very confusing from the standpoint of differential diagnosis. In a district infested with yaws the reaction is of no value in diagnosing syphilis. However, the treatment of the two diseases being the same, the reaction is of great value from the standpoint of indicating the need of salvarsan therapy. While a positive test in yaws, as in syphilis, presupposes infection, a different estimate must be placed on the behavior of the reaction following treatment with neosalvarsan. This is due largely to the fact that yaws is ordinarily much more amenable to treatment and a few injections not infrequently effect a complete cure, although the Wassermann reaction may remain positive for several months afterward, gradually becoming weaker, however, and eventually negative, without further injection of neosalvarsan. It is unnecessary therefore to continue treatment until a negative reaction is obtained. In syphilis, on the other hand, the test often becomes negative under intensive treatment only to become positive again when injections are discontinued. Neither yaws nor syphilis can be regarded as completely cured so long as a positive test persists, but in yaws a cure may be presumed on the disappearance of clinical evidence of activity, and no further treatment is necessary unless the reaction persists or becomes stronger after the lapse of many months.

Although in the case reported by Shamberg and Klauder the Wassermann reaction became negative with alcoholic extract of syphilitic liver and acetone insoluble antigen and 1 + as recorded in their chart, and 2 + as stated in the text, in a scheme in which 4 + indicated complete fixation, the authors nevertheless considered the infection still present. Evidently they were applying to yaws the same significance which experience has taught attaches to a persistence of a positive reaction in syphilis. Interpreted in the light of our results, one is justified in assuming that their case was cured and that in a few months the reaction would have become negative spontaneously.

In the absence of clinical manifestation of activity a negative Wassermann test must be the final criterion of a cure in yaws. Consequently, the reaction should be used to establish the efficacy of any treatment of yaws such as with tartar emetic as used by Castellani; and in latent yaws, where clinical evidences are slight, it should be of utmost importance in determining the effect of treatment with neosalvarsan or other methods.

From the standpoint of diagnosis, the Wassermann reaction is of value in recognizing latent yaws and in differentiating tropical ulcers that may be benefited by neosalvarsan from those that have no relation to either syphilis or yaws.

SUMMARY

1. The Wassermann test was strongly positive in 100 per cent of 45 patients presenting active cutaneous lesions of yaws.
2. Complement-binding strength of titrated serum from yaws is equal to the maximum strength of syphilitic serum.
3. Following the clinical cure of yaws by intravenous injection of neosalvarsan the Wassermann reaction remained positive for many months, gradually weakened, and became negative in seven of twelve cases within six months after treatment.
4. Treatment of yaws in the early secondary stage with mercury caused no noticeable improvement in the lesions. The Wassermann reaction showed an initial slight weakening in the titre, then remained constant and strongly positive.
5. An antigen prepared from an early yaw containing treponemata did not fix complement with sera from yaws patients that were strongly positive with the usual cholesterinized antigen.

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IMMUNITY IN YAWS

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TWO PLATES

The question of immunity in yaws has received scanty attention, notwithstanding its clinical importance and its theoretical interest. The experimental data and even the clinical observations are extremely meager.

The clinical evidence bearing upon the immunology of yaws is complicated by wide variation in opinion concerning the spontaneous course of the natural infection. Since the introduction of salvarsan therapy the opportunity no longer exists of following individual patients through the entire course of the disease. The clinical picture must be built up from the composite study of many individual cases seen at varying stages of the infection. Some observers question the existence of a tertiary stage, believing that the disease ends with the disappearance of the secondary eruption. Others lean decidedly toward the view that, after the secondary stage, the infection lies dormant or continues with tertiary manifestations practically throughout life.

The evidence of tertiary manifestations rests chiefly upon clinical grounds and not upon any exact demonstration in the laboratory. Perhaps the clearest indication of tertiary involvement is to be found in the bone lesions. These develop not uncommonly in children during a typical attack of yaws. The Wassermann reaction is positive, and the symptoms yield to salvarsan therapy. The possibility must be considered of a double infection of syphilis and yaws. However, in a community where syphilis is uncommon, and when the patient and his family show no taint of the disease, a syphilitic etiology of these bone lesions is practically excluded.

The question of establishing spontaneous cure presents some difficulties. On several occasions, children showing a typical infection of yaws were brought to the clinic at Parañaque by their parents who stated clearly that they themselves had had yaws in childhood and recovered spontaneously without any sequelæ. They had full confidence in their immunity and handled their children without fear of reinfection. The Wassermann reaction of six of these adults was taken and found to be negative in all but two instances.

Briefly, we feel convinced that in a large number of cases the disease terminates spontaneously at the end of the secondary stage, while in others the infection lies latent or proceeds to tertiary manifestations. There are no data available from which even approximate percentages can be estimated. Moreover, it is likely that the late manifestations of the disease vary somewhat in different localities in the Tropics. In Santo Domingo, large numbers of extremely bad cases of clavos were seen. In Parañaque some effort was required to find clavos cases, and the lesions were not extensive.

The available clinical evidence indicates that the majority of patients, after passing through the secondary stage, are not likely in later years to experience a return of the typical granulomatous eruption. Immunologically, distinction must be made between a sterilizing immunity and a refractory latent infection preventing reinfection. The treponemata of yaws may behave, on the one hand, like the spirochætes of relapsing fever which many believe produce true immunity; or, on the other hand, they may behave like the treponemata of syphilis.

These points have been investigated by the reinoculation of yaws in one group of patients during the secondary stage of the disease, and in another group some months after treatment with neosalvarsan. The dosage was regulated according to the table in the fourth paper of this series. These patients coöperated cheerfully and faithfully in all of this work, and for no recompense except the treatment with neosalvarsan which they received.

REINOCULATION OF YAWS PATIENTS DURING THE SECONDARY STAGE

It was assumed, on clinical grounds, that patients in the primary or the early secondary stage of the disease could be readily reinfected with yaws. The secondary lesions do not differ from the primary ones in any respect. Successive crops appear from time to time in such patients for a period of many

months, developing usually metastatically, though occasionally perhaps by direct accidental inoculation.

The material for the first inoculations was secured by removing the yellow crust from a well-developed yaw and scraping the surface firmly with a scalpel. The exudate thus obtained always contained a moderate amount of blood, and no precautions were taken to insure the removal of visible pieces of tissue. Smears of this material were subsequently stained by Giemsa's method. Usually treponemata were very scanty. Observers frequently speak of the very abundant spirochætes seen in smears from yaws nodules. We have not found spirochætes in large number except secondary invaders, distinct from the causative treponema. This material was reinoculated immediately in an incision through the skin, made sufficiently deep to cause a slight oozing of blood. The skin over the deltoid muscle was selected for the site of inoculation, since this area is not ordinarily involved spontaneously. The work was conducted under dispensary conditions, and it was not feasible to make observations oftener than at intervals of one week. The details are as follows:

In the first case the disease was of two months' duration at the time of reinoculation, the mother yaw being present and active. There was also a generalized papular eruption over the trunk and the lower extremities. The inoculations were made in three incisions. A week later they had healed completely. Observations were continued for a period of six weeks, and no changes occurred at the site of inoculation. In the meantime, however, typical multiple granulomata developed elsewhere over the body. The patient was given neosalvarsan.

The second case had developed a mother yaw five months previously and now showed five secondary granulomata. Three incisions in which the inoculations were made healed promptly and remained entirely negative during the six weeks' period of observation. Treatment with neosalvarsan was commenced.

In the third case the disease was of four months' duration, the mother yaw being present. One month after its appearance, the patient was vaccinated against smallpox and a typical granuloma developed at the site of this vaccination. Numerous papules also appeared over the face and the body; several developed into typical granulomata. Material from one of these was reinoculated into three incisions of the skin over the deltoid. The incisions healed promptly; during the next six weeks some additional granulomata developed but none appeared

at the site of inoculation. Treatment with neosalvarsan was commenced.

Some of the earlier observers report the successful inoculation of yaws in normal individuals with the production of a generalized eruption but without the development of a primary lesion at the site of inoculation. Usually, however, a mother yaw develops just as in the spontaneous disease. Paulet(9) inoculated 14 normal men successfully with yaws and in 10 a local lesion developed. Charlouis(4) inoculated 32 Chinese prisoners, in 28 of whom yaws developed; in each case a local lesion appeared at the point of inoculation. Nicholle(8) inoculated 8 men successfully but in 3 no primary lesion developed.

There is no evidence that any of the reinoculations of our three cases was successful. Another group of four patients was selected and inoculated in the same manner. These patients were well advanced in the secondary stage. Indeed, the onset of the disease had occurred so long ago that it was not possible to determine with certainty even the approximate date. In all of these cases, however, the secondary stage had existed for at least eight months. The inoculations were made in the same manner as in the three cases mentioned, two incisions being made in the skin over the deltoid. The incisions healed promptly and no fresh granulomata developed elsewhere over the body. Two weeks later three patients of the second group were reinoculated on the opposite arm. Care was taken to implant a small piece of tissue from the yaws granuloma. A superficial incision was made in the patient's skin and the piece of yaws tissue was caught in a nick in the cut edge. The incision soon filled with blood which clotted firmly over the implanted tissue. Subcutaneous implantation was avoided on account of the possibility of secondary infection. In two of these patients the result was entirely negative. In the third, one week after inoculation, the upper incision had healed completely. A slight but distinctly elevated ridge had formed along the entire line of the lower incision 0.5 centimeter in length. At the end of the second week a small round lesion, 3 millimeters in diameter and 2 millimeters in height, had developed. One week later, this granuloma had increased a little in size and the skin immediately surrounding it was slightly hyperæmic. At this time, it seemed that the lesion was commencing to grow rapidly. However, one week later the granuloma was distinctly smaller and the hyperæmic zone had disappeared. A photograph was

taken (Plate 1, fig. 1) showing this lesion and also, in poor focus, some spontaneous granulomata on the neck. Treatment with neosalvarsan was commenced at this time.

Two other cases of yaws of a very different type were reinoculated. Both of these were cases of clavos who had recovered spontaneously from the granulomatous stage many years ago. It seemed desirable to test experimentally the possibility of producing a typical granuloma in patients during the late stage of the disease.

Both of these patients gave clear intelligent histories. One had typical yaws twenty years ago and now has thickened and excoriated skin over the soles of both feet and similar lesions in the palm of one hand. When the patient is at work there is moderately severe pain. The other patient had a granulomatous eruption of yaws of three years' duration ending ten years ago. He now has moderate thickening and excoriation of the skin over the sole of one foot only. There is practically no pain. Neither of these men has had any return of the granulomata. The Wassermann reaction was performed and showed complete fixation in both cases. There was nothing in the history or examination of these patients suggestive of syphilitic infection.

Implantation of yaws tissue was made in two incisions in the skin over the deltoid in each patient. One week later a papillary eruption was developing rapidly at the site of each implant in both patients. At the end of the second week, however, the reactions had almost completely subsided, no suitable material being available even for microscopic study. The observations were discontinued and neosalvarsan injections were commenced for the treatment of clavos.

INOCULATION OF PATIENTS WITH YAWS AFTER TREATMENT WITH NEOSALVARSAN

A group of four cases of yaws in the secondary stage received treatment with neosalvarsan. Nearly six months later, small pieces of yaws tissue were implanted in an incision in the skin. Observations were continued for four and one-half months. Some instructive results were obtained. In one patient, a typical granuloma developed at the site of inoculation and progressed rapidly; with the appearance of early secondary lesions, neosalvarsan was given. In the other three patients, small granulomata appeared after a short time at the site of

inoculation and then disappeared spontaneously in two of these cases. The details of these four cases are briefly as follows:

In the first patient, seen September 19, 1921, the mother yaw appeared on the forehead and was first noticed three months ago. It is now about the size of a peso (about 3.5 centimeters.) The secondary lesions appeared one month after the mother yaw. At present there are numerous granulomata over the forehead, the neck, in the right axilla, over the chest, the abdomen, and both legs, as well as numerous small papules. Recently there has been pain in the bones. One injection of neosalvarsan was given. The pain in the bones disappeared, and the lesions healed so rapidly that the patient did not return to the dispensary until October 3. At this time the granulomata had almost entirely disappeared. A second injection of neosalvarsan was given, and two weeks later there was no discernible evidence of any active lesion.

The Wassermann reaction on September 19 showed complete fixation with 0.1 cubic centimeter of patient's serum. On October 12 the titre had not changed, 0.1 cubic centimeter giving complete fixation. On March 2, 1922, the reaction was negative.

On March 9, 1922, this patient was reinoculated with yaws, two incisions of the skin being made about 1 centimeter apart. A small piece of tissue was excised from the surface of an active yaw from a patient in the early secondary stage and was used for the inoculation of this group of 4 patients. One week later (March 16) these incisions had healed with very slight elevation of the skin. At the end of the second week (March 23) both incisions showed a very distinct elevation. At the end of the third week (March 30) characteristic granulomata had developed at each of the two sites of inoculation and they were surrounded by a bright red areola. The appearance at this date is shown in the accompanying photograph (Plate 1, fig. 2). Blood was taken for a Wassermann test, and the reaction was negative. A week later (April 6) the two granulomata had coalesced into one. At the end of the fifth week (April 12) there were numerous, minute, discrete papules over the body surrounded by a hyperæmic area. These were presumably the beginning of the secondary lesions. There was no sign of regression in the mother yaw. One injection of neosalvarsan was given, and the lesions disappeared promptly.

The second patient was seen first on September 12, 1921. He contracted yaws "much more" than one year ago. The scar of the mother yaw could still be seen in the right popliteal space.

There have been successive crops of secondary lesions; the scars of several can still be seen plainly on the chest and the abdomen. Granulomata have persisted continuously around the anus. The first injection of neosalvarsan was given at this time. September 21 the lesions have almost completely dried. A second injection of neosalvarsan was given. October 3 the patient appeared clinically cured; nevertheless, a third injection of neosalvarsan was given.

The Wassermann reaction on September 12 showed complete fixation with 0.01 cubic centimeter of serum in a system designed for the use of 0.1 cubic centimeter of patient's serum. On October 12, 0.005 cubic centimeter gave complete fixation. On March 9, 1922, 0.1 cubic centimeter gave partial fixation and 0.01 allowed complete hæmolysis. On this date, minute pieces of yaws tissue were implanted in incisions of the skin about 0.5 centimeter apart. The patient was not seen again until two weeks later. At this time both incisions showed distinct elevation. At the end of the third week (March 30) the elevated ridge of epithelium along the upper incision was drying up. At the lower incision there was a small dry papule. The appearance is shown in the accompanying photograph (Plate 1, fig. 3). The Wassermann reaction taken at this time showed the same titre as on March 9. At the end of the fourth week these epithelial lesions had desquamated completely, leaving only the barely discernible linear scar of the incision. On May 16, the Wassermann reaction still showed the same titre as on March 9 and March 30. No more Wassermann tests were taken; a final clinical observation was made July 20, there being no suggestion of any lesions of the skin.

The third patient was seen September 22, 1921. The mother yaw appeared almost two years ago, and the patient is certain that it healed more than one year ago. There are numerous evidences of healed secondary lesions on various parts of the body. There is one cluster of granulomata on the back of the neck now, but the lesions are dry and show signs of regression. For three months the patient has noticed pain in the bones of the hands and the feet. The first injection of neosalvarsan was given at this time. October 3 the pain in the bones has disappeared, and the skin lesions have cleared up completely. A second injection of neosalvarsan was given.

The Wassermann reaction on September 22 showed complete fixation with 0.1 cubic centimeter of serum and almost complete fixation with 0.01 cubic centimeter. On October 12, 0.1 cubic

centimeter gave complete fixation, but complete hæmolysis occurred with 0.01 cubic centimeter of serum. On March 2 the reaction was negative with 0.1 cubic centimeter of serum.

On March 9, 1922, tissue from a yaw was implanted in two incisions of the skin about 0.75 centimeter apart. A week later (March 16) these incisions showed nothing more than ordinary healing. At the end of the second week however (March 23) each of these incisions showed a broadened elevated ridge of epithelium. One week later (March 30) these lesions were beginning to dry and regress. They are illustrated in Plate 2, fig. 1. The Wassermann reaction at this time was negative. At the end of the fourth week (April 6) these small lesions had desquamated completely. The final observation was made on July 20.

The fourth and last case came to the dispensary on September 12, 1921. An active mother yaw was present on the left wrist. According to the history it appeared eight months ago. There are numerous secondary yaws over the forehead and neck, around the eyes and mouth, on the right hand and wrist, over the scrotum, in both popliteal spaces, and on the right ankle. Neosalvarsan was injected on this date. September 21 the skin lesions are only partially healed. A second injection of neosalvarsan was given which resulted in complete disappearance of the skin lesions.

The Wassermann reaction on September 12 showed complete fixation with 0.01 cubic centimeter of serum, and almost complete with 0.005 cubic centimeter. On October 24 complete fixation occurred with 0.1 cubic centimeter of serum, but hæmolysis was almost complete with 0.01 cubic centimeter. On February 17, 1922, the reaction was negative with 0.1 cubic centimeter of serum.

The inoculation with yaws was made on March 9, 1922, in two incisions about 1 centimeter apart. At the end of the first week (March 16) there was a slight suggestion of elevation of the epidermis along the line of healing. At the end of the second week (March 23) this elevation was definite, and a week later (March 30) at the lower incision a small definite granuloma had developed, 7 millimeters in its longest diameter and about 2 to 3 millimeters in height. It appeared rather inactive, as though spontaneous regression was about to set in. A photograph was taken (Plate 2, fig. 2) and the lesion excised for histological study. A section through this tissue shows a polymorphonuclear

leucocytic infiltration of the epithelium. The epithelial layer is very thin in the center and is covered by leucocytic exudate. On either side, the epidermis is slightly thickened and filled with fluid and cellular exudate. The superficial layer of corium is acutely inflamed, showing dilatation of capillaries, œdema, and polynuclear cell exudate. Below this there is a dense infiltration with large and small lymphocytes and a few plasma cells. There is also a mononuclear cell exudate about the sweat glands. The appearance is characteristic of yaws. A Levaditi preparation shows no treponema.

The other lesion developing at the upper incision was not disturbed, in order to determine whether it would regress spontaneously. The Wassermann reaction was practically negative. At the end of the fourth week (April 6) the lesion along the upper incision had disappeared completely. Primary healing had taken place along the line of excision of the granuloma removed for study; however, one month later, six small granulomata developed with some induration of the underlying tissue. These gradually coalesced into one large yaw. The appearance on May 25 is shown in the accompanying photograph (Plate 2, fig. 3). It was not pedunculated as might possibly be inferred from the illustration.

At this time there was no suggestion of any secondary lesions, and the primary yaw had begun to regress gradually. On June 20 an area representing almost one quarter of the yaw had practically healed along the upper edge of the yaw. Some weeks later, however, there was a slight extension of the yaw along its lower edge. The remainder of the body was entirely free from any lesions of the skin. On July 13, a little more than four months after inoculation, treatment with neosalvarsan was commenced.

On reinoculating these four cases with yaws the urine was tested for arsenic biologically, using *Penicilium brevicaule.* The results were negative, but the control tests were not entirely satisfactory. However, neoarsphenamine is excreted rather rapidly after intravenous injection. Moreover, the results in these cases could hardly be explained by incomplete excretion of arsenic.

TREATMENT WITH SERUM

In addition to these investigations on the effect of reinoculation, some observations were made on the supposed beneficial action of the serum of patients undergoing salvarsan treatment.

Alston(1) treated a small series of yaws cases in 1911 with salvarsan. The supply of the drug being limited, he tried the effect of injecting serum taken from cases of yaws several days after the injection of salvarsan. Pronounced improvement occurred and, what is more surprising, serum collected from the cases treated with serum produced beneficial results on injection into yaws patients. Such a striking phenomenon is of distinct interest immunologically. It is very suggestive in certain aspects of the occurrence in vivo of the d'Herrelle phenomenon.

Two papers were published by Alston. In the first, the striking improvement following the injection of serum was noted. In the second paper Alston stated that all of the cases treated with serum improved for two or three weeks. Thereafter they either remained stationary or became worse; but he expressed the belief that, if the injection of serum had been continued, the patients would probably have gone on to complete cure. These papers have been misquoted in the literature, the impression being given that actual cures were obtained. However, from the standpoint of immunology, striking improvement would be of great importance.

The details of Alston's work are as follows: Salvarsan (606) was given to adults in the secondary stage of yaws in full doses intramuscularly. Four to five days later, a cantharides blister was applied to two cases and the resulting serum was collected. This serum was injected (perhaps intramuscularly) in several yaws patients, in quantities of 16 cubic centimeters for the adult dose. Improvement was noted fully as rapidly as after salvarsan, changes being noticeable in some cases after sixteen hours.

A second group of yaws cases was injected with salvarsan, and serum collected from them produced rapid improvement when injected in yaws patients. The cases receiving serum were blistered with cantharides, and the resulting fluid was injected into two boys in a dosage of 8 cubic centimeters each. Improvement commenced promptly. Alston conducted several control experiments, the more-important results being that (*a*) blister fluid from normal persons and (*b*) from untreated yaws cases showed no beneficial effect, and (*c*) the heated serum from treated yaws cases was efficacious even after boiling. Rost(10) supplied the salvarsan for this work and observed the cases treated with serum. He confirms the striking improvement noted by Alston.

This work was repeated with the introduction, however, of some modifications. Neosalvarsan was injected intravenously, and serum was obtained by taking a specimen of the patient's blood several days later.

An adult yaws patient in the active secondary stage was injected with 0.75 gram neosalvarsan. Four days later blood was drawn by direct puncture from a vein of the arm. The specimen was kept on ice for three hours and the serum removed. Three patients with typical granulomata of yaws were injected. A child of 11 years of age received 20 cubic centimeters intramuscularly; another, 6 years old, received 10 cubic centimeters intravenously; and another, 4 years old, received 5 cubic centimeters intramuscularly. No improvement followed in the succeeding week. These patients were then injected with neosalvarsan and responded promptly.

A second adult patient with florid secondary yaws was given 0.6 gram neosalvarsan intravenously. Two days later, 200 cubic centimeters of blood were withdrawn and stored overnight on ice. Serum was injected into two patients showing active secondary lesions. One, 14 years old, received 20 cubic centimeters intravenously, but no improvement followed. The other, a child of 5 years, was given 12 cubic centimeters intramuscularly. Three days later some of the granulomata were slightly drier than at the time of injection. The change however was very slight and not greater than might occur spontaneously. Another injection was given intramuscularly of the serum, which had been stored on ice, using 12 cubic centimeters. No improvement followed. Both of these cases responded promptly to neosalvarsan.

Taking into full consideration the modifications we have introduced, it is difficult to explain the discrepancy between our results and those obtained by Alston.

DISCUSSION

The reinoculation of yaws patients before and after treatment with salvarsan appears to us to afford a valuable procedure for the study of immunity in this disease. The data recorded in this paper are rather meager, but the results are fairly clear-cut and at least serve as an outline of the various types of reaction that may be expected. The following interpretation is based upon the character of the reaction obtained and is entirely independent of the percentage of successful inoculations:

Untreated cases.—It is noteworthy that many failures followed the inoculation of scrapings from a yaw in patients during the secondary stage of the disease. This suggests that the secondary granulomata do not arise readily from accidental transference by the patient to abrasions in various parts of the body. Reinoculation during the primary stage of the disease might give a high percentage of "takes;" the results in the secondary stage are of more interest. The failures we obtained are in marked contrast to the results recorded by Charlouis. This observer in 1881 carried out a large series of a variety of human inoculations of fundamental interest and significance. The records are given with such brevity, however, that no analysis of the data is possible. Of four patients who were reinoculated, three developed papillomata. On reinoculating two of these patients, one was positive. Jeanselme and Angier(5) reinoculated a fully developed yaws patient four months after the onset and, again, five months later. The results were negative.

In our work, reinoculation in the late granulomatous stage resulted only once in the development of a lesion. The most striking characteristic of the experiment was the prompt spontaneous regression of the lesion. This seems to us to indicate that a definite though not complete resistance to reinoculation develops during a long-standing infection.

Charlouis also inoculated ten individuals who had recovered from yaws. In seven the result was positive, the disease running virtually the same course as in normal individuals who were experimentally infected. It is obviously impossible to state whether these individuals were actually cured of their infection or were merely in a latent stage, and the number of years that had elapsed since the onset of the disease is not known.

Treated cases.—The small group of yaws patients that were reinoculated after treatment with neosalvarsan permits some interesting observations. Only one of four cases developed a typical, actively growing granuloma, and this patient had been infected for only three months, the mother yaw being present as well as secondary lesions at the time treatment with neosalvarsan was started. Obviously this period of infection was inadequate to establish any protection against the somewhat severe test of experimental inoculation. One of the other patients had been infected eight months, the mother yaw also being present at the time the injections of neosalvarsan were

started. On reinoculation, slow-growing granulomata developed at each of the two incisions, and after three weeks spontaneous regression set in. The larger of the two lesions was excised and, subsequently, numerous small granulomata appeared at the site of excision, excited perhaps by the surgical trauma. The lesion which was left undisturbed disappeared completely. In the other two patients the infection had persisted for more than a year, and the mother yaw had disappeared completely when the injections of neosalvarsan were given. Both of these patients developed abortive lesions which disappeared promptly.

Of the many possible interpretations of these results it seems plausible to us that these abortive reactions are due to an active immunity and are analogous in a general way to the immediate temporary reaction following the vaccination of individuals immune to smallpox. Indeed, it is the only example with which we are familiar of an abortive reaction developing with a virus for which the etiologic microörganism has been established. It is often difficult to distinguish between active immunity and latent infection resulting in a refractory state. The latter assumption is not plausible in these cases of yaws. The striking effect of neosalvarsan upon *Treponema pertenue*, the prompt disappearance of the clinical manifestations, and the gradual weakening or disappearance of the Wassermann reaction are strong arguments indicating the radical cure of the disease.

Our results throw some light upon the spontaneous course of yaws. After the development of the mother yaw, successive crops of secondary granulomata develop, for the most part by metastatic infection. The Wassermann reaction becomes positive and, also, a measurable degree of immunity slowly develops. This immunity is not sufficient to produce regression of the granulomata already formed, but it seems to be effective eventually in preventing metastatic infection, thereby gradually bringing about the termination of the secondary stage and, frequently, of the disease itself. In other cases, latent foci of infection persist in the bones and in the thickened epidermis of the feet and hands, lasting for many years or throughout life.

The question of recidives in yaws has often been loosely discussed from a clinical standpoint. It involves two aspects; namely, (*a*) whether a patient in the late or tertiary stage of yaws may suffer a recrudescence of the typical secondary or granulomatous stage, and (*b*) whether a patient actually cured of the disease and free of treponemata may experience a typical

reinfection. Our experiments on the reinoculation of clavos cases suggest that latent cases are not likely to develop typical granulomata. The immunity in yaws is not high in degree, and one attack of the disease does not necessarily afford protection against reinfection.

Cross immunity in yaws and syphilis.—In the lower animals, with the exception of the higher apes, the available evidence indicates that experimental yaws terminates spontaneously with the primary stage. A large amount of work has been conducted with the object of determining the relationship between yaws and syphilis. Experiments have been made upon animals and even upon man. With one exception, neither cross protection nor modification of the course of either disease has been observed. A man who had developed yaws was inoculated by Charlouis with syphilis. A typical chancre and characteristic secondary eruption developed. A second patient infected with yaws contracted syphilis naturally, the disease running a typical course in the primary and secondary stages before treatment was commenced. Bahr,(2) on the other hand, noted that in Ceylon syphilis and yaws do not coexist in the same community, and that in Fiji yaws prevails very widely while syphilis is unknown, although there is frequent opportunity for its introduction. He considers that in man a reciprocal protection is developed between the two diseases.

Neisser, Baerman, and Halberstädter,(7) working in Java, found that monkeys successfully inoculated with syphilis were also susceptible to yaws, and vice versa. These findings were confirmed independently by Castellani.(3) Somewhat different results were obtained by Levaditi and Nattan-Larrier.(6) Monkeys infected with syphilis were protected completely against yaws. The results of these experiments might well vary slightly according to the stage of the disease at which the cross-inoculations were performed. Before concluding that yaws affords no protection whatever against syphilis, it would be desirable to demonstrate that some degree of immunity had been established to yaws itself before testing the resistance to syphilis.

Notwithstanding the discrepancies in the clinical and experimental evidence, the accepted opinion to-day leans decidedly to the conclusion that the two species, *Treponema pertenue* and *T. pallidum*, which have so many characteristics in common, do not afford any substantial cross-protection. It is reasonable to assume that, in the process of evolution, these two species arose from a common ancestor. There is no ground, however, for any

profitable speculation concerning the circumstances which led to their differentiation. It is clear from the preceding discussion that the exact extent of this differentiation has not been clearly determined in its biological aspects.

SUMMARY

1. A patient, in the well-developed secondary stage of yaws, was successfully reinoculated with yaws; the lesion soon regressed spontaneously.
2. Two patients in the stage of clavos were reinoculated with yaws. The lesions that developed disappeared very rapidly.
3. The reinoculation of untreated patients suggests that a long-standing infection with yaws produces a definite though not complete resistance to reinfection.
4. Four patients in the secondary stage of yaws were treated with neosalvarsan and reinoculated with yaws several months later. In one a typical granuloma was produced; in the other three atypical reactions resulted.
5. The results of reinoculation of patients cured with neosalvarsan indicate the development of a measurable degree of active immunity in yaws.
6. No evidence was obtained to suggest that the serum of yaws cases under treatment with neosalvarsan has any curative action when injected in yaws patients.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Untreated patient, reinoculated with yaws, experimental lesion over the deltoid. Some spontaneous granulomata on the neck.

2. Treated patient, reinoculated with yaws, first case; lesion at the end of the third week.

3. Treated patient, reinoculated with yaws, second case; lesion at the end of the third week.

PLATE 2

FIG. 1. Treated patient, reinoculated with yaws, third case; lesion at the end of the third week.

2. Treated patient, reinoculated with yaws, fourth case; lesion at the end of the third week.

3. Fourth case, showing condition of lesion eleven weeks after inoculation.

PLATE 1.

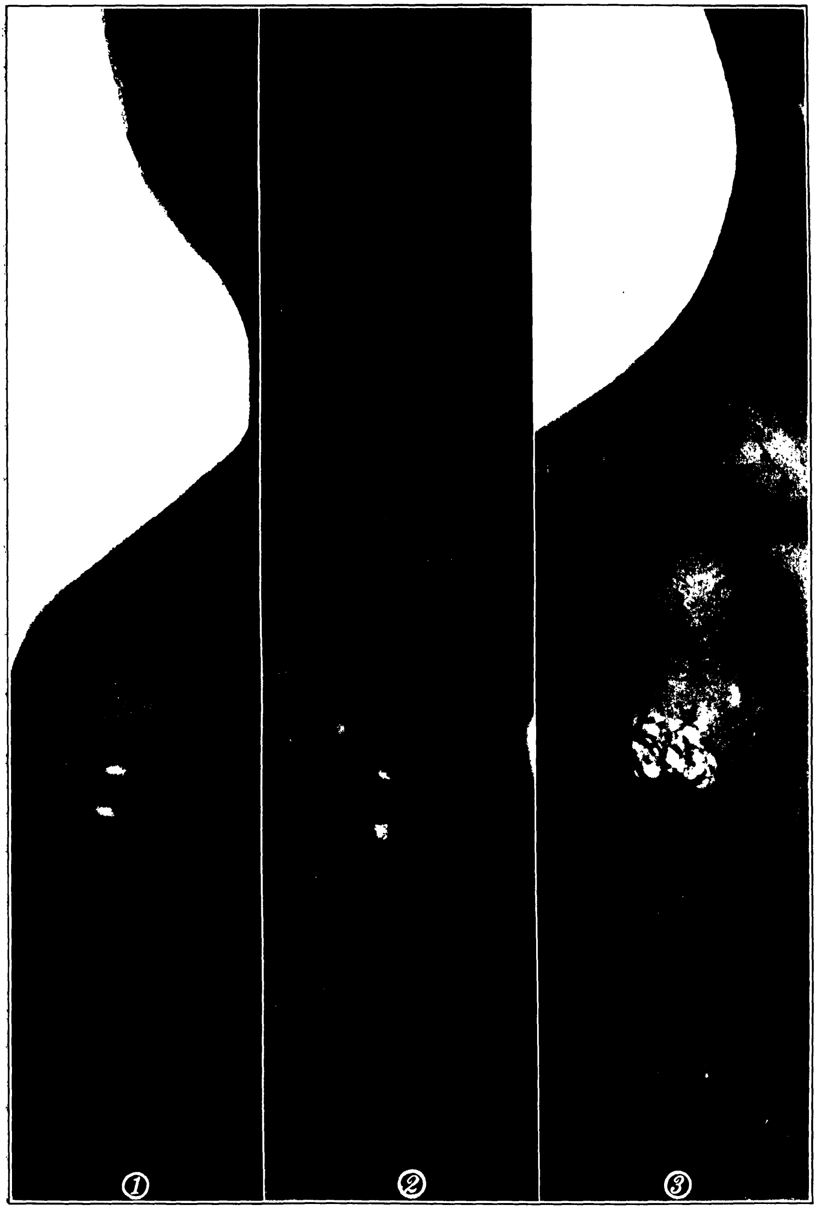

PLATE 2.

PUBLIC-HEALTH ASPECTS OF YAWS

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DISTRIBUTION

Yaws is one of the comparatively few diseases that are limited rather sharply to the Tropics. It encircles the globe in the Torrid Zone, but curiously enough it does not spread when introduced into temperate climates. There are a few records of an occasional isolated case contracted outside of the Tropics, but the disease does not gain a foothold there. Maxwell(8) states that yaws is imported into China from the Straits Settlements from time to time, but soon dies out. These statements apply to the distribution of yaws as it occurs today; it is believed by some authors that certain of the diseases formerly endemic in Ireland may have been yaws.

In several instances the geographical restriction of infectious diseases is readily explained by the corresponding limitation of an essential insect vector. The interest which such sharp limitation arouses is well illustrated by the striking though incompletely studied example of verruga peruviana and oroya fever. These diseases occur in the Andes Mountains and are endemic at altitudes of approximately 1,500 to 7,000 feet (500 to 2,300 meters). Patients when removed to higher or lower altitudes do not serve as foci of infection. Moreover, susceptible individuals may remain in the infected zones during the daytime with impunity, but before nightfall they must proceed to a higher or lower altitude. Hence the inference is drawn that these diseases are transmitted by a night-flying insect limited to this region.

Even within the Tropics it is commonly stated that yaws is restricted to the lower altitudes. Bahr(2) noted in Ceylon that people living at altitudes higher than 800 feet (260 meters) rarely contract the disease, even though the surrounding lowlands are thoroughly infected. A striking exception has been reported by Ricono(10) who describes eight cases in

the Mount Fletcher District in South Africa; Mount Fletcher is 5,500 feet (1,800 meters) high.

In Manila, for many years, physicians have frequently spoken of the occurrence of yaws in the Mountain Province of northern Luzon at elevations varying from 2,500 to more than 5,000 feet (800 to 1,700 meters). I recently passed through this province on a brief visit. In exceptional instances, I found that yaws occurring in the people there might readily have been contracted during visits to the adjacent lowlands where the infection is prevalent. This explanation, however, does not apply in the majority of cases. Doctor Pick, of the Philippine Health Service, estimates that he has treated 2,800 cases of yaws in the Mountain Province. He describes the lesions as limited largely to the mouth, the anus, and the vulva, with but few granulomata occurring on other portions of the body.

The limitation of yaws to the Tropics inevitably suggests that it may possibly be transmitted by bloodsucking insects in analogy with other spirochætal diseases such as relapsing fever. This idea has been emphasized by Bahr. In its support it should be mentioned that the mother yaw frequently develops on the lower extremities, which recalls that, in bubonic plague, the causative organism is commonly introduced in the lower extremities, the initial buboes appearing in the groin.

Although the circumstantial evidence, suggesting an intermediate insect host, should not be forgotten, it seems advisable to adhere to the prevailing view that yaws is ordinarily disseminated by contact. The only feasible procedure for attempting the control of yaws in a given community consists in eradicating the foci of infection by treatment of the individual patient.

No plausible suggestion has been advanced concerning the probable explanation of the usual restriction of yaws to the warmer regions of the Tropics. In seeking for a solution, it is perhaps well to keep in mind the possible effect of surface temperature upon the development of the granulomata. Considering first the typical case of the lowlands, it is noteworthy that, of the multiple miliary lesions distributed metastatically from the mother yaw, only a small proportion progress to fully developed granulomata. Although these granulomata may develop on any part of the body, they show a striking predilection for the muco-cutaneous orifices, for the axillæ, and also for the groin and the popliteal spaces. These locations

are either moist or they are protected, to some extent, by the body clothing. However, in the Mountain Province of the Philippine Islands it would seem that the majority of the patients escape the usual general distribution of yaws over the body. These people are very primitive. The men wear only a breechcloth, and the clothing of the women is inadequate to maintain the ordinary surface temperature of the body. The possibility naturally suggests itself that, in the dry skin exposed to the low temperature, the granulomata of yaws might develop only with difficulty.

INCIDENCE

In drawing up any detailed plans for the treatment of yaws in an endemic area, one is often embarrassed by the impracticability of securing even an approximate estimate of the total number of cases. On making inquiries, one is frequently told that almost everybody has fresh active yaws. To assume that such is the case would be a fallacy. There is considerable clinical and also some experimental evidence that the majority of patients do not pass through more than one period of typical florid granulomatous eruption. Let us allow the fairly liberal period of two years for the granulomatous stage and assume an average duration of life of fifty years for the community. Considering the disease to be endemic rather than epidemic, the maximum number of cases in the granulomatous stage would average 40 per 1,000 of the population. Obviously such a calculation is merely of theoretical interest. In Parañaque, yaws has been endemic for many generations; recently the Philippine Health Service treated nearly all of the active cases. There were 275 cases in a population of 8,541, or 33 per 1,000 of the population. Unfortunately, in many isolated districts of the Tropics even an approximate census of the population is not available.

The disease is restricted almost entirely to the native people and especially to those of the poorer classes who are inclined to give scant attention to simple personal hygiene. In many localities, yaws might well be classed as one of the diseases of childhood. At the Parañaque clinic 69 per cent of the cases occurred in children under 11 years of age, and the total of those under 16 years was 88 per cent. At Yamasá in the Dominican Republic the parents freely make a practice of exposing children to the disease because they feel that the sequelæ,

especially clavos, are likely to be less severe when the disease develops during infancy.

DIAGNOSIS

For public-health purposes, the diagnosis of the typical granulomatous stage is a simple matter. Secondary pyogenic infection may mask or confuse the diagnosis. Some of the atypical infections may require a little care in differentiating them from cutaneous leishmaniasis, from granuloma inguinale, and from syphilis. Indeed, in obscure cases, it may be impossible, even with the most-refined means of investigation, to differentiate absolutely some of the tertiary lesions of yaws from tertiary syphilis. The X-ray is of assistance in differentiating the bone lesions of the two diseases. Real difficulty arises in the case of ulcers. The history may be wholly unreliable; and the clinical manifestations, the laboratory findings, and the response to treatment are inadequate for differentiating syphilitic and frambœsial ulcerations.

For the purpose of simply checking the spread of yaws in a community it is perhaps sufficient to treat only the primary and secondary stages. We have found no reliable indications in the histories of patients that a mother yaw has been contracted from a tertiary case. On a priori grounds it seems improbable that a tertiary ulcer would afford a serious focus of infection for the spread of the disease.

On humanitarian grounds, and for the sake of relieving the extensive incapacitation caused by the late lesions of yaws, it is imperative to extend the treatment to latent cases. In some regions, the condition known as clavos is especially important. Multiple granulomata develop in the thickened epidermis of the soles of the feet. An attempt at healing takes place and a hard core of tissue forms in the center which eventually falls out leaving deep "nail" holes. Hence, in Spanish-speaking countries, this condition is often called "clavos." Excoriation and fissuring of the epidermis continues, and the pain persists. The results of the serological tests and the therapeutic response indicate strongly that active infection with the causative treponema is responsible for the continuance of these lesions.

Finally, a word must be said in regard to the control of field work by the Wassermann reaction. The decision regarding the advisability of including a Wassermann outfit in the

field equipment is probably an individual question and might well be allowed to vary according to local conditions. It is certainly superfluous for the diagnosis and treatment of the ordinary granulomatous stage, being indeed without value as a guide in the immediate effect of treatment. The Wassermann reaction is of distinct value in eliminating some of the nonspecific ulcers which would not be benefited by salvarsan. As a means of diagnosis the more practical procedure could be substituted of the therapeutic test of injecting salvarsan. Unfortunately this procedure is slow, and the results are often masked by the extensive secondary infection. The employment of the Wassermann reaction requires at most only one additional member in the personnel and adds immeasurably to the satisfaction of the work.

TREATMENT

No difficulty whatever exists in deciding upon the remedy which is most suitable for field use. Neosalvarsan at present stands alone in its efficacy, its relative ease of administration, and its availability. Nevertheless, it is a powerful agent and must be employed judiciously by medical men, or under their immediate personal supervision. From the viewpoint of modern hospital practice, intravenous injection is often regarded as the ideal attainment in therapy. Indeed, to many it would seem to be a step backward to suggest oral administration in place of intravenous injection. However, a drug which is efficacious only when injected into the tissues of the body suffers a very real limitation in its general use even in a modern community. For example, the control that exists over malaria to-day in the better-regulated communities would be greatly hampered if quinine could be administered only by injection by trained individuals.

The various salvarsan preparations fall short of the ideal in this requirement for they are not sufficiently efficacious when administered by mouth for the practical treatment of yaws. Brochard(4) reported fairly successful results in the treatment of nine cases of yaws with old salvarsan administered by mouth. Recently Doctor Albert, in association with Doctor Rosal at the Philippine General Hospital, has tested the oral administration of salvarsan in the treatment of yaws. Neosalvarsan given in dilute solution in daily doses of 60 milligrams was borne without serious nausea by children of 12 years of age. After a week of treatment no noticeable improvement had occurred.

Old salvarsan was then given in gelatine capsules by mouth in daily doses of 150 milligrams. Improvement was noticeable within a week and was very well marked after two and a half weeks. These cases have not yet been reported in full. It is evident, however, that the oral administration does not produce sufficiently rapid improvement to permit its employment in field work. The same objection applies to Castellani's treatment with tartar emetic. With the impatience typical of the average patient, the treatment would not be voluntarily continued until a cure was effected. Indeed, it has not yet been demonstrated serologically that the administration by mouth of either salvarsan or tartar emetic will effect the absolute cure of yaws.

However, there is some ground for encouragement in the fact that salvarsan given by mouth does produce very definite improvement in yaws. It hardly seems to be an unreasonable chemical requirement that effective derivatives should eventually be produced suitable for oral administration in the radical cure of yaws. Indeed, this might afford a preliminary step toward the enlargement of the field for treating and controlling the related disease, syphilis.

A very real question comes up in deciding whether neosalvarsan should, under field conditions, be injected intravenously or intramuscularly. The former is the method of choice, but the number of men available for the Tropics who are adequately trained in the very simple technic of intravenous therapy is surprisingly limited. Moreover, successful injection in a difficult vein, with only untrained assistants to hold the child, perhaps in the uncertain light of the rainy season, requires a greater degree of skill than is necessary in a modern hospital. The procedure is relatively laborious and time-consuming. On account of the contamination with blood, a fresh syringe must be used for each injection. According to the United States Public Health requirements, a minimum of five minutes must be employed for each intravenous injection. Therefore, exclusive of all the time for the preparation of materials, one individual under these restrictions can hardly inject more than ten patients per hour. On the other hand, for intramuscular injection a single syringe, by merely changing the needle, can be used repeatedly without resterilization, and one individual can, without special effort, inject two or three times as many cases as in intravenous work. I have had considerable expe-

rience in Santo Domingo with both methods. After six weeks of intravenous work at Monte Plata, intramuscular injection was adopted at San Cristobal where two hundred cases of yaws in the granulomatous stage were treated. At the outset, it was hoped that the slow absorption from the intramuscular injection would largely obviate the reactions. The results were disappointing in this respect; the reactions were very common, and some of the chills were severe. The therapeutic results however were excellent; the lesions healed promptly, and very few patients required more than two injections. These results are not surprising in view of the accepted teaching regarding the pharmacological action of the salvarsans. According to the consensus of opinion, salvarsan per se is not efficacious against the treponema, but it is readily oxidized in the tissues to a more active product. In the gastrointestinal tract there is no tendency toward oxidation, but in the blood stream oxidation takes place easily, and in the muscles it occurs still more rapidly.

The most serious drawback to the intramuscular procedure consists in the very extensive and at times painful induration at the site of injection. Absorption takes place very slowly. In some communities this method of treatment would seriously injure the confidence of the people, and it would be essential to employ intravenous injection.

To many it may seem very radical to recommend such a toxic agent as neosalvarsan for mass treatment in field operations. However, it was successfully employed in Santo Domingo for more than 1,200 patients. This was accomplished without any trained workers for assisting during the injection or in the immediate after-care of the patients. It was necessary to violate, in minor respects, many of the conditions laid down by the United States Public Health Service for the administration of neosalvarsan. In the first place an excellent grade of distilled water was prepared almost daily in the camp for making up the solutions. However, a sufficient supply of distilled water was not available for boiling syringes; rain water especially collected from a clean canvas tent was employed, although the water remaining in the syringes necessarily contaminated the solution of salvarsan slightly. In the intravenous injection of children, especially a struggling child, it was by no means possible to adhere to the required time of five minutes for the entire injection. For the sake of economy,

the main stock of neosalvarsan was obtained in 3-gram ampules; and, here again, with the various delays incident to injection, it was often impossible to complete the injection of the entire quantity of solution within thirty minutes after its preparation; occasionally as much as forty-five minutes was required. Also, since no ice was available, the solution was always prepared with water at summer temperature. No control could be exercised over the diet or the preliminary catharsis of the patients. In view of these drawbacks, doses slightly smaller than the standard were employed. The scheme of Bergen(3) was modified as shown in Table 1.

TABLE 1.—*Dosage of neosalvarsan.*

	Bergen.		Modified scheme.	
	Age.	Dose.	Age.	Dose.
	Yrs.	*mg.*	*Yrs.*	*mg.*
Adults		900		600
Subadults	18 to 20	750	18 to 20	500
Do	16 to 17	600	16 to 17	450
Do	10 to 15	450	10 to 15	400
Children	7 to 10	300	7 to 9	300
Do	5 to 7	225	5 to 6	225
Do	3 to 5	150	3 to 4	150
Infants	2 or less	75	2 or less	75

This table is intended, of course, only as a general guide for the various ages or, in many instances, for the apparent or the probable age. Obviously, the dosage must occasionally be reduced, or treatment deferred altogether in patients showing marked emaciation, outspoken pulmonary or cardiac disease, and also in febrile conditions other than those due to yaws. The infrequency of arteriosclerosis and renal insufficiency in the Tropics eliminates any necessity for routine examination of the urine.

Other methods of treatment have been recommended, more especially for avoiding the use of injections under unfavorable conditions. Castellani's formula(5) containing potassium iodide and tartar emetic has met with considerable favor; however, this treatment must be continued daily for approximately one month. An adult, or a child over 14 years, must take 300 grams or more of potassium iodide. The cost of this item alone is rather more than 4 pesos as contrasted with 1.8 grams of neosalvarsan at about 0.80 peso.

When one is cut off for weeks from a base of supplies, the essential equipment for the treatment of yaws with neosalvarsan is not complicated, even in regions where the simplest articles of household life are wholly lacking. The exact details will vary with the preference of the individual. The following unit was found practical, and is suggested as a suitable basis for the selection of an outfit:

1 small water still with tin condensing coil.
2 bottles (0.5 liter) for receiving distilled water.
A supply of suitable water for washing and boiling syringes.
1 khotal or primos stove with complete set of wrenches and pliers and fine wire for cleaning and soft leather for repacking the piston. (New models have a valve for regulating the size of the flame.)
10 gallons of kerosene, allowing 1 quart for ordinary use of stove continuously for eight hours. Alcohol for priming stove.
1 small box for shielding the stove from drafts. This is essential. The wooden case commonly used for two 5-gallon oil cans is satisfactory.
12 syringes, Luer type, 10 and 20 cubic centimeters capacity (for intravenous work), an ample supply of needles, and a stone for daily sharpening of these. If steel needles are used alcohol and ether saturated with vaseline are convenient for drying them when not in use.
2 pairs of ordinary forceps.
2 wide-mouthed bottles 100 cubic centimeters (with glass stopper or cover) with graduation marks. (A mark at 60 cubic centimeters for dissolving 3-gram ampules of neosalvarsan at the minimum dilution of 0.1 gram per 2 cubic centimeters. Additional graduations can be made with a syringe.)
1 container (of tin) for boiling water for dissolving salvarsan.
1 container for used syringes.
2 copper instrument boilers (25 by 12 by 6 centimeters) with removable tray and with wire tongs for handling tray. Soap, alcohol, and cotton for preparation of patients.
2 soft rubber tourniquets.
2 triangular files.
1 set of cards for records of patients. (Cards are preferable to a bound book for convenience in locating a patient's record on his return visits.)
Ampules of salvarsan. (3 grams each for the main stock with a few small ampules, 0.6 gram each, for convenience in adjusting the quantity of solution required in closing the day's work.)
Schedule of dosages for varying ages.
Stethoscope.
Clinical thermometers and reagents to test for albumin in the urine.

The main cost of the work is the expense of personnel for the administration of neosalvarsan. Fortunately, in some localities in the Philippines, the Government hospitals with their person-

nel are already available. In these it would be entirely feasible to treat yaws continuously. There are other regions, heavily infected, in which traveling dispensaries could be operated intermittently. The expense of neosalvarsan for Government use is remarkably low; namely, 20 cents United States currency (40 centavos Philippine currency) for 0.9-gram quantities. Therefore, for a series of three injections of 0.6 gram each for an adult, the total cost of the drug would be 80 centavos Philippine currency. The majority of the cases, however, occur in children; for an infant the neosalvarsan for a series of three injections costs 10 centavos.

The total expenditure in money that would be required to bring yaws under control in a given community would necessarily vary widely in different countries. Moreover, if the work were to be pressed rapidly, it would be correspondingly much more expensive. The time required must also vary widely. It would depend in the main upon three factors; namely, (*a*) the readiness with which patients present themselves for treatment; (*b*) the consistency with which they return for repeated injections; and (*c*) the total percentage of cases that report for treatment.

In primitive communities we have found that the people would await with interest the result of the injection of the first few patients. Then they would present themselves even more rapidly than desired. There are always, however, a few stragglers. Moreover, with the striking benefit following one or two injections, there are many who do not bother to return for repeated injections. Furthermore, one cannot expect that 100 per cent of the cases will report voluntarily and with reasonable promptness. The operation of a dispensary for a single period of a few weeks for the treatment of all accessible patients in a given area would certainly be altogether inadequate to bring the disease under permanent control. Repeated visits would be required at intervals of perhaps six or twelve months. Six months after closing the dispensary at Parañaque, an inspection showed the presence of 76 cases of yaws. They were classified as follows: Fifty-six cases were reported to have developed since the closing of the dispensary; 8 were old cases that failed to report for treatment; 12 were only partially cured or were relapses. Too much confidence cannot be placed on this small number of relapses, since two-thirds of the cases received only one injection. In several places a good beginning has been made, only to have the preliminary advantage lost through a

gradual or sudden decline in interest resulting in merely spasmodic activity or even in cessation of the work.

PERMANENCY OF RESULTS

The available data indicate that there is but little tendency to recurrence or reinfection after treatment with salvarsan. In the Windward Islands in 1912–1913, only 5 per cent of relapses occurred after treatment with salvarsan (606).(1) Bergen noted 4.9 per cent of relapses, or possibly reinfections, following the intravenous treatment of 1,626 cases of yaws with salvarsan after a period of thirty-four months; 2.6 per cent of relapses occurred in 655 cases treated intramuscularly. Kurien(7) records 11 per cent of relapses in the treatment of about 3,000 cases with various preparations of salvarsan, but apparently 90 per cent of the patients received only one injection. Thorough treatment of a community at once reduces to a minimum the foci of infection. It is probable that, having once had the disease, many patients will profit by their lesson.

Fairly extensive treatment of yaws has been practiced of late years, particularly in some of the hospitals of the West Indies. There are doubtless valuable reports from such hospitals to which I have not had access. Indeed, it would be very important to secure information concerning the incidence of yaws in a community in which intensive treatment with salvarsan had been practiced consistently for several years. In Java, in 1913, the treatment of yaws with salvarsan (606) was given thorough consideration. The decision was referred to Kloppers,(6) who concluded that the plan was not feasible on account of the great expense of salvarsan at that time. McDonald,(9) in 1915, suggested measures leading to the absolute eradication of yaws in Antigua, a small island of about 108 square miles in the Leeward group in the West Indies.

SUMMARY

Neosalvarsan in the hands of medical men can, with proper precautions, be used safely on an extensive scale under field conditions. The diagnosis of the granulomatous stages of yaws is simple. A Wassermann outfit, though not indispensable, is a valuable adjunct even in field work. The treatment presents no special difficulties. In the Tropics, routine examination of the urine is not a prerequisite before administering neosalvarsan.

Certain details of field operations are still sub judice, or are subject to modification according to varying local conditions.

It has not been accurately determined whether latent or tertiary cases of yaws constitute important sources in the infection of susceptible individuals. Further observations are desirable regarding the feasibility of substituting intramuscular for intravenous injection of neosalvarsan, especially when work is conducted under the disadvantage of limited personnel.

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THE HISTOLOGY OF HEALING YAWS

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TWO PLATES

The rapid curative effect of neosalvarsan upon the cutaneous lesions of yaws is probably the most spectacular achievement of modern chemotherapy. Disfiguring and loathsome sores, oozing pus and blood for months, will begin to dry and encrust a day or two after an intravenous injection of this drug, and in an incredibly short time will fade away almost magically. Since Strong,(12) in 1910, first demonstrated his successful results in the treatment of yaws with salvarsan, many observers have commented upon the immediate improvement in gross appearance of lesions following this treatment, but it has been impossible to find any description of the more minute changes that take place in the tissues of the nodules. The rapid encrustation and dropping off, so to speak, of a lesion which is known to be largely an epithelial hyperplasia, is difficult to explain from gross appearances alone. It was consequently of interest to determine what happens to the causative organisms, and how such a sudden subsidence of the inflammatory process is brought about.

Through coöperation with the Philippine Health Service at Parañaque and the Philippine General Hospital it was possible to excise suitable lesions before and at varying lengths of time after treatment, and a description of the histopathology of these specimens is the basis of the present paper.

There are several excellent descriptions of the typical cutaneous lesion of yaws. Many of them, and some the best, were made before *Treponema pertenue* had been demonstrated by Castellani(1) to be the etiological agent, and they are therefore incomplete. Others were based upon study of a single example, consequently presenting only one stage; but, taken altogether, this phase of the pathology of the yaw has been carefully studied and our understanding of the inflammatory process is fairly

complete. One still undetermined point is how the secondary lesions begin and where they begin—whether in the corium or in the epidermis.

Practically all the histological studies of human material have evidently been made with lesions from the eruptive stage of the disease following primary local infection. There can be no reasonable doubt that this exanthem is due to the localization in the skin(2) of treponemata from the circulating blood entering through the mother yaw. Whether they pass through capillaries and papillæ into the epidermis without obvious effect and there proliferate, injuring surrounding tissue, or whether their initial growth with primary inflammatory reaction is in the perivascular tissue of the papillæ with secondary invasion of the epidermis is uncertain.

Charlouis,(3) describing in 1881 the histology of a pinhead-sized papule, thought the primary changes occurred in the corium. He described a dilatation and tortuosity of the superficial plexuses and then of the deeper vascular plexuses accompanied by a diapedesis of leucocytes, an elongation of the papillæ, and an infiltration of granular cells between the fibers of the corium. Pontoppidan(7) in 1882 placed the primary seat of the affection in the prickle-cell layer of the epidermis. Macleod(4) in 1901 carefully described several stages of the eruption and concluded that in the earliest skin manifestation which, following Nicholle, he called the "squame," the initial stage occurred in the superficial layers of the corium as was evidenced by a slight dilatation and tortuosity of the papillary and subpapillary vessels in the neighborhood with a marked extravasation around them of leucocytes which passed therefrom into the lymphatic spaces between the fibrous bundles and eventually reached the epidermis. In 1907 Schüffner(9) demonstrated *Treponema pertenue* for the first time in sections, by the silver method, and found the organisims only in the epidermis. Later investigations(6, 10, 8) have confirmed this observation on the limited distribution of the organisms, and Siebert(11) is of the opinion that they proliferate only there, because of the activity of cocci from the surface which stimulate a local leucocytic exudate favorable for their growth. In some of my preparations, as will be described later, treponemata were demonstrated in great numbers in the perivascular tissue about the terminations of papillæ; for this and other reasons it seems probable that the secondary yaw begins with a lesion in the papillæ and spreads

from there to the epidermis where conditions of growth are subsequently more favorable.

However, following the first and yet undetermined lesion, there are continued injury and reaction which result in a fully developed papillary nodule. The architecture of the nodule is well known, the essential feature of it being a small papule, or papillary, frambœsiform granuloma, irregularly round or oval, discrete or confluent, elevated a few millimeters to a centimeter or more above the surrounding skin, and covered in its earlier stages by a soft yellow scab, beneath which is a granular seropurulent, sometimes hæmorrhagic surface formed of elongated papillæ, almost reaching the exterior and bleading easily, with thickened epidermis between. Later the surface is drier and coated with keratinized epithelium. Microscopically the epidermis is greatly thickened, swollen with fluid, infiltrated with leucocytes distributed diffusely and as miliary abscesses. The epithelium is prematurely desquamated and shows various degenerative changes, later developing a hyperkeratosis. The elongated papillæ are œdematous, hæmorrhagic, and infiltrated with cells of various types, and deeper in the corium are dense aggregations of mononuclear cells; in the earlier stages those of the large lymphocytic type predominate, but later the aggregations are composed almost entirely of plasma cells, a stage which Unna (13) described. Several observers note the absence of vascular thickenings and of definite perivascular cellular infiltration in the corium, in contrast to cutaneous lesions of syphilis.

In the following descriptions the histological structure of stages observed will be considered in detail with the changes noted in them following treatment by intravenous injection of neosalvarsan.

MATERIAL AND METHOD

Typical early secondary yaws of from one to four months' duration were removed from four individuals before they had received treatment. From one of these persons (case 1) a second yaw, as nearly at the same stage of development as possible, was excised forty hours after intravenous injection of neosalvarsan. From another (case 2) a second yaw was excised three days after treatment and a third seven days. Only lesions removed before treatment were studied from the remaining two cases of early yaws (cases 3 and 4).

From a fifth case a dry, apparently regressing or stationary lesion of four or five months' duration was removed before treatment, and another similar nodule three days after an injection of neosalvarsan.

Sections of nodules from each case, measuring 1 millimeter in thickness, were immediately placed in Zenker's fluid and in 10 per cent formalin. The Zenker-fixed material was embedded in paraffine and stained with hæmatoxylin and eosin. The formalin-fixed tissue was stained by Levaditi's silver method.(5)

CASE 1

Primary yaw appeared on the ankle four months previously, followed in one month by a crop of secondary papules over the entire body, accompanied by occasional attacks of fever, chills, and pain in the bones. Many of the lesions increased in size until at present they measure from 0.5 to 1 centimeter in diameter. They are discrete, elevated, rounded or oval nodules, the surface fungating and covered by an opaque, yellow, moist crust.

Yaw 1.—October 8. Such a yaw on the chest, measuring 0.8 centimeter in diameter, was excised by Doctor Franco under local anæsthesia. On cut section it showed a firm, grayish yellow, thickened epidermis containing a few minute hæmorrhages, evidently in an acute stage of inflammation. Pieces of tissue were fixed immediately in 10 per cent formalin and in Zenker's fluid.

Microscopically there is an acute inflammation of the skin, with an enormous exudate of leucocytes in the thickened epidermis and a serous, in places hæmorrhagic, exudate in the elongated papillæ of the corium. The acute inflammatory changes in the corium are confined almost entirely to the lengthened and swollen papillæ and to a thin zone just beneath the basal layer of epithelium elsewhere. The reaction is characterized especially by an exudation of serum which spreads apart collagen fibrils and fills up the spaces between them. To a less extent leucocytes and red cells are present in this perivascular tissue; in places fibrin is deposited and small hæmorrhages have occurred.

Corresponding to the elongation of papillæ the total width of the epidermis is about fifteen times the normal, and most of this increase in volume is due to the accumulation of leucocytic and serous exudate within this layer. Foci of leucocytes occur in the form of miliary abscesses which are numerous and situated most characteristically in a midzone somewhat nearer the

corium. The upper portion of hair follicles does not escape invasion. Leucocytes are also scattered in greater or lesser numbers throughout the epidermis in intercellular spaces. These spaces are dilated by the presence of serous exudate. A thin layer of purulent exudate, often communicating with miliary abscesses below, overlies the surface. There is no ulceration through the epidermis, though the abscesses sometimes break through the basal layer. There are various degenerative changes in epithelial cells; some are pale and shrunken, others vacuolated especially about the nucleus, and many are cast off into abscess cavities where they undergo hyaline necrosis. Normal differentiation is arrested, keratinization does not occur, and nuclei are preserved more or less intact out to the surface. There is an absence of general pigmentation in the inflamed area, though in Levaditi preparations large, branching, pigment strands can be found here and there in the stratum germinativum. Mitotic figures in epithelial cells are abundant.

In the œdematous perivascular connective tissue, which is relatively poor in cells, there are, in addition to the polymorphonuclear, a considerable number of the large mononuclear type, which however are rarely engaged in phagocytosis; this is in striking contrast to the condition in yaw 2, following treatment. The large mononuclear cells are fairly numerous also in miliary abscesses. There are a few lymphocytes and there is a moderate increase in fibroblasts, some of which are to be found in mitosis, but no plasma cells appear.

In the superficial layer of the corium there is a mononuclear infiltration, but this is not nearly so abundant as in case 2. Most of the cells are of the lymphocytic type, though small groups of plasma cells are to be found, and there are many polymorphonuclears. The arrangement is perivascular. The mononuclear-cell exudate does not extend so deeply into the corium as in case 2 but, even so, there are a few plasma cells accumulated about coils of sweat glands. Eosinophiles are not numerous in the lesion, but there are a few irregularly scattered both in the corium and in the epidermis.

Levaditi preparation.—Sections stained by Levaditi's silver method disclose an enormous number of treponemata, especially in the epidermis. They are present in great abundance in the miliary abscesses and in areas of epidermis densely infiltrated with leucocytes. A few can be found in the epithelium at the margins of abscesses where there is no cellular infiltration. Here the treponemata lie in the dilated intercellular spaces, and even

within the cells themselves, especially those showing necrosis or advanced degeneration. No definite evidence of phagocytosis of the organisms by leucocytes has been observed, but in those miliary abscesses which appear oldest, as indicated by leucocytic disintegration and more superficial situation, the organisms are much less abundant than in the newly forming ones which lie deeper in the epidermis. From this it is inferred that the treponemata disintegrate and disappear gradually in the presence of abundant polymorphonuclear leucocytes.

While the epidermis is undoubtedly the most favorable site for the growth of these organisms they are not in this lesion entirely confined to the epithelial layer, but occur in great numbers in œdematous perivascular connective tissue in certain of the long papillæ which extend far up into the thickened epidermis. They are present only in the terminal portions, and in only a few papillæ.

Yaw 2.—October 10. Forty hours after the injection of 0.3 gram of neosalvarsan intravenously the lesions are pinkish instead of yellow and purulent, less elevated, and much improved. Yaw 2, measuring 0.7 centimeter in diameter, was removed by Doctor Franco.

Even in so short a period there is marked change in the histological picture, especially of the epidermis. On the surface is a thin layer of leucocytes and desquamated epithelial cells sometimes communicate with the remnant of a miliary abscess deeper down; but miliary abscesses and foci of dense cellular infiltration are rare within the epithelial layer. There are still great numbers of leucocytes irregularly scattered throughout the epithelial layer, lying in intercellular spaces and sometimes aggregated in small nests, but the great mass of them have been cast off onto the surface or removed in other ways. The thickened and elongated epithelial columns are much more compact than in the previous section, due largely to the loss of intercellular exudate.

The papillæ extending upward into the thickened epidermal layer are still greatly swollen by serous, fibrinous, and cellular exudate and by dilated blood vessels and capillaries. Polymorphonuclear cells appear to be more numerous in the perivascular exudate than before treatment, but their conditions are essentially altered. Many are being engulfed in great numbers by the phagocytic activity of large mononuclear leucocytes, which appear now to be the most active component of the lesions; others are necrotic.

Large mononuclear phagocytes are present in great numbers and are not confined to the papillæ but are to be seen in considerable abundance in interepithelial spaces, engulfing leucocytes wherever they find them. The cytoplasm of many is filled with the digesting remains of these cells, and they are present in no less abundance in the corium where they are also engaged in phagocytic activity, picking out only polymorphonuclear cells which lie among plasma cells and lymphocytes in a number exceeding that of the previous lesion. These active cells are removing leucocytes rapidly from the lesion, not only by local digestion but by transportation, as is indicated by their presence in dilated lymphatics; otherwise, there is no observable change in the cellular exudate. Eosinophiles are present, as in the previous lesion, but they are not being phagocytized. Small accumulations of fibrin at the tips of certain papillæ are invaded by mononuclear cells which have assumed the shape and appearance of epithelioid cells. Some of the vessels of the papillæ contain fibrin thrombi thus invaded.

Levaditi preparation.—These sections show no treponemata. It thus appears that following injection of neösalvarsan treponemata are rapidly destroyed and disappear from the lesion. With the removal of this active pathogenic agent reparative processes immediately ensue.

CASE 2

Four months previously the mother yaw developed on a finger. One month later secondary lesions appeared over the entire body, accompanied by swelling and pain over bones and joints. Lesions on arms, legs, and feet were only macules and dried up; those on the face, neck, chest, and hands have grown to be typical yaws measuring 0.5 to 2 centimeters in diameter, elevated and, when first seen, moist and semitranslucent, having a yellowish, honeylike surface. Ten days later, at the time of removal of the first lesion, they are still soft but more opaque, yellow, and mottled, with small hæmorrhages.

Yaw 1.—September 1. A yaw measuring 1.5 centimeters in diameter having the above-described yellow, purulent, and hæmorrhagic appearance was excised by Doctor Franco from the left side of the back after the injection of novocaine about its margins. The yaw was totally removed with a portion of corium beneath. Sections 1 millimeter thick were immediately fixed in 10 per cent formalin and in Zenker's fluid.

Section through the freshly excised nodule shows a smooth, fairly firm, moist, semitranslucent, grayish and yellowish cut surface of greatly thickened epidermis contrasting with the softer, more-pliable corium beneath. There is no crust, only a thin layer of seropurulent exudate on the rather coarsely granular surface. Near the surface are minute reddish purple points, evidently hæmorrhages in the epithelium. The gross appearance shows that the yaw is essentially a thickening of the epidermis, in which there is an acute inflammatory exudate but no distinct ulceration. The thickened epidermis measures 3 millimeters in width.

Microscopical examination.—The pieces of tissue fixed in Zenker's fluid were embedded in paraffine in the usual way and thin sections stained with hæmatoxylin and eosin, carbol-anilin-fuchsin for bacteria, and by other special methods.

Microscopically there appears a violent acute inflammation of the epidermis and the immediately underlying corium. One is at once impressed by the greatly elongated papillæ of the corium and the deep penetration of corresponding intervening epithelial pegs. The total width of the epidermis is more than twenty times normal. The most acute exudate is within the epidermis and at the apices of papillæ. Over the apices of many of those papillæ, which extend outward often almost to the surface, and in the surrounding epidermis, there is extensive hæmorrhage, the red cells often lying enmeshed in a coarse network of fibrin. Here and there are small pockets of the granular coagulum of serum; but the most abundant and characteristic component of the exudate is the polymorphonuclear neutrophilic leucocyte. Such leucocytes are present everywhere in enormous numbers throughout the swollen, distorted, and hyperplastic epidermis. They are most numerous in a zone just above the basal layer of epithelium, and least numerous in the deep, thick, epithelial pegs and hair follicles. They occur in the form of discrete or confluent miliary abscesses, rupturing, pushing aside, and dissolving masses of epithelium. They lie in great numbers diffusely scattered throughout wide areas within intercellular spaces between shrunken epithelial cells which are pushed apart by quantities of intercellular fluid, and they wander less conspicuously, but still in great numbers, between the cells of the less-injured epithelial pegs and hair follicles. They sometimes accumulate in dense groups at the tips of papillæ beneath the epithelium, and not infrequently a miliary abscess within the

epithelium ruptures through the basal layers and becomes bounded below the connective tissue of corium. The elongated and widened papillæ and a thin layer of corium just beneath the basal epithelial cells constitute the least cellular portion of the lesion. Here a loose reticulum of collagen fibrils, the wide interstices of which are filled with serous exudate, support enormously dilated blood vessels and gaping lymphatics. There is an active diapedesis of polymorphonuclears going on, and they are the most numerous cells. There are in addition a few plasma cells, fewer lymphocytes, and a number of fibroblasts evidently greater than could be normally present. Many of the smaller blood vessels and lymphatics must also have been produced in the general inflammatory activity.

Beneath this zone of œdema the denser corium is filled with compact masses of mononuclear cells which fade off into the depths of the corium in the form of small isolated cellular islands. Where infiltration is densest the collagenous connective tissue has been pushed apart and its fibrils separated until only a thin wavy reticulum remains. While blood vessels of various sizes course through these areas, the distribution of cells is so extensive that there can hardly be said to be a perivascular arrangement, although deeper in the corium there is distinct perivascular infiltration. The majority are plasma cells with numerous lymphocytes which not infrequently form the nucleus of a group with the periphery bounded by a thick zone of plasma cells. There is also a generous sprinkling of polymorphonuclears, especially on the more superficial side. In the depths of the corium there is a cellular infiltration not only about blood-vessels but also about coils of sweat glands and, to a less extent, about hair follicles. These infiltrations are plasma cells and lymphocytes. There are a few hyaline plasma cells, but no giant cells. Mast cells are not abundant.

There is a rather peculiar distribution of polymorphonuclear eosinophiles in the lesion. They are not abundant but occur unexpectedly in groups in certain parts of the epidermis. The cellular exudate of a minute abscess may be entirely composed of them, or in wide areas none may be found. In the œdematous zone of the corium their distribution is irregular; only in certain places do they form almost a complete sheath about small blood vessels.

Levaditi preparation.—Sections 1 millimeter thick were fixed in 10 per cent formalin and stained by Levaditi's silver method.

In proportion to the degree of acute inflammation present, few treponemata were found. The organisms are most numerous within and about the hæmorrhages in the epidermis.

Yaw 2.—On September 2, this man received 0.75 gram of neosalvarsan intravenously; a rise in temperature and intense pain over the body followed.

September 5, three days after treatment, the lesions showed a distinct change. They were dry on the surface and showed a bright pink, healthy color instead of the yellow seropurulent discharge previous to treatment. There appeared to be a thin, unpigmented, transparent film of epithelium covering the papillary crests disclosing the bright color of the circulating blood beneath, and in the center a soft thin crust. The surface was otherwise clean, no pus to be seen. Under local anæsthesia Doctor Franco removed a small yaw, measuring 0.8 centimeter in diameter. Sections 1 millimeter thick were immediately fixed in 10 per cent formalin and in Zenker's fluid.

In gross the cut surface is gray and semitranslucent without the yellow tint of pus or the appearance of hæmorrhage. There is obviously less fluid exudate.

Microscopically there is very great change, most marked in the epidermis. On the surface is a thin layer of leucocytes and desquamated epithelium with beginning cornification. The evidences of exudation have almost completely disappeared; only a few straggling leucocytes caught in intercellular spaces remain in the site of previously great activity. The still deeply penetrating and interlacing columns of epithelium are compact and sharply outlined. Mitotic figures are numerous and though the cells, even of the basal layer, are larger than normal there is no appreciable excess of intercellular fluid. Large, branching pigment strands, while relatively sparse, are more numerous than in the previous section.

The papillæ of the corium present more evidence of the previous inflammation. Many of these are still greatly enlarged and turgid with fluid exudate. The interstices between collagen fibrils are filled with a clear, pink-staining, gelatinous material, like thick serum, within which are vacuoles. The blood vessels are not noticeably dilated, but the lymphatics are remarkably so. These areas contain relatively few cells; the majority are plasma cells and polymorphonuclears. There are appreciably more hyalinized plasma cells than were observed in the section before treatment.

The cellular exudate in the deeper portions of the corium appears the same as in the previous section, unless there is a relative increase in the number of polymorphonuclears and lymphocytes, and more hyalinization of plasma cells.

Levaditi preparation.—Sections stained by Levaditi's silver method show no treponemata. The pigment strands of the stratum germinativum stain conspicuously.

Yaw 3.—On September 9, the yaws were changed still more in gross appearance; since the 5th they assumed a dark slaty color, having lost completely their red tint. They were drier and beginning to form a scaly crust (hyperkeratosis), loosened about the margins.

Under local anæsthesia Doctor Franco removed a yaw measuring 0.7 centimeter in diameter. Cut sections show an irregularly thickened and firm epidermis, but the general consistency, especially of the corium, is softer than that of previous lesions. The corium has a slaty color.

Sections, microscopically, show a continued progress toward normal skin. Except for a slight excess of interstitial fluid in some of the papillæ there is a complete absence of evidence of acute inflammation. There are no polymorphonuclears, and both lymphatics and blood vessels have resumed their usual size. The epidermis is becoming rapidly readjusted. It is much thinner than in the previous sections and there is marked hyperkeratosis. Even in the deep epithelial pegs there is advanced keratosis, great central whorls of keratinized cells giving the appearance of small dermoid cysts. Individual epithelial cells are nearing the normal size and degree of compactness. There is a greater abundance of pigment in the form of large branching strands and of intra-epithelial granules situated in the stratum germinativum. There is also an abundance of pigment-bearing cells in the corium, which evidently gave the slaty tone noted in gross. The connective tissue of the corium is compact, but there is little change in the mononuclear exudate present in this layer. It remains abundant and composed of plasma cells and lymphocytes. Plasma cells are relatively less numerous than in previous sections, and hyalinized forms seem to be increased in number. There are less eosinophiles than previously noted and practically no polymorphonuclear cells.

Levaditi preparation.—Levaditi's method discloses no treponemata in the lesion.

HISTOLOGY OF THE YAW

The above observations on the histopathology of well-developed early yaws agree in most particulars with those of previous investigators. I have been more impressed perhaps than the majority by the degree of acute injury and reaction in the papillæ, especially in the earlier stages, and am of the opinion that the first local inflammation occurs in this portion of the skin, with secondary involvement of the epidermis. The presence of acute exudate and focal accumulation of polymorphonuclear cells in the corium of the youngest papule studied, a papule 2 millimeters in diameter from case 3, and the demonstration of treponemata in the perivascular tissues of papillæ in another fresh lesion (case 1), together with the recognition of an apparent necessity for the secondary eruption of yaws to begin with a localization of organisms from the circulating blood about smaller blood vessels of the skin, have urged upon me the acceptance of this conception of the beginning of the lesions.

The presence beneath the epidermis of treponemata of the species *Treponema pertenue* has not to my knowledge been observed before; and it is, indeed, a very curious fact that their distribution in demonstrable numbers is practically always limited to the epithelial layer. Here are certainly in later stages the optimum conditions for their growth, notwithstanding the fact that they may live in and be distributed by the circulating blood. This strict limitation in distribution is a noteworthy contrast to the disposition of the closely related *Treponema pallidum* which seems to find a more-favorable environment in connective-tissue spaces.

The purulent exudate in the epidermis is undoubtedly a reaction to the presence there of treponemata, and not a result of secondary invasion by pyogenic cocci from the surface, as was suggested by Unna who was not acquainted with the etiological agent of the disease, and thought probable by Siebert who, finding the treponemata only in association with the exudate, was inclined to think this a prerequisite for their localization. But the mass of leucocytic exudation and the greater number of miliary abscesses are situated nearest the basal layers of epithelium, and here treponemata are in greatest numbers and other organisms are absent. Nearer the surface treponemata diminish in numbers even in the miliary abscesses, and cellular exudate is abundant, while on the surface bacteria are present.

It appears in sections from case 1 that the margins of abscesses are extended by invasion of surrounding tissue by treponemata, and leucocytes accumulate about masses of these organisms lying within and about necrotic epithelial cells. With the destruction of the etiological agent all acute inflammation rapidly subsides. Finally, leucocytes and miliary abscesses and treponemata may be found in basal epithelium in young papules showing no evidence of surface infection.

Treponemata may be found in great numbers within the pockets of hæmorrhagic, serous, and purulent exudate, and they are less numerous in the dilated intercellular spaces of the epidermis and within degenerated epithelial cells. They can also be demonstrated within serous and cellular exudate about terminal vessels of papillæ. These organisms are the source of injury. In their presence epithelial cells become swollen or shrunken, their nuclei pallid or hyperchromatic and distorted. Many of them, becoming necrotic, are apparently dissolved as in miliary abscesses. Their injurious action extends to the vascular bed of the papillæ and the corium. Capillaries are dilated; their walls are injured, and hæmorrhage and cellular exudate ensue. With the accumulation of serum and cells within the epidermis the epithelium is further injured and its normal differentiation is arrested. There is a loss of pigmentation, and cornification is absent. Leucocytes and red blood cells are exuded upon the surface, fibrin is deposited, and serum oozes through the intercellular spaces. Along with this exudation epithelial cells are disrupted and thrown off prematurely. With surface evaporation a superficial scab is formed. In the meantime the epithelium of the basal layer actively multiplies and, as the papillæ project upward, the epithelial pegs correspondingly pierce downward. Mitotic figures are numerous in the irregular stratum germinativum, and the margins of this layer are for the most part definitely outlined, though occasionally ruptured by accumulating exudate within, and sometimes apparently by the growth of treponemata and resulting injury about the apical terminations of papillæ without. Not infrequently large branching pigment strands are seen in the basal layer ramifying among intercellular spaces, but isolated pigment granules are rare. Differentiation of the hair shaft is arrested, and one finds in the depths of hair follicles abortive shafts and hyaline epithelial pearls. Cells of sebaceous and sweat glands do not appear to be injured, although there is frequently a mononuclear exudate about the latter. Larger branches of nerves and erector

pili muscles seem as usual, and there are no vascular lesions deep in the corium. About the cellular accumulation in the corium there is a moderate proliferation of fibroblasts.

SPONTANEOUS HEALING

Nearly all the nodular cutaneous lesions of yaws in the course of time undergo spontaneous healing. After they have become well developed the process is a tedious one and may extend over a period of months or years, those on the palms of the hands and soles of the feet being especially chronic. Most of the macules and papules of the secondary eruption regress before they reach the frambœsiform stage. After the frambœsiform appearance is attained, regressive changes become manifest, such as drying of the surface and the formation of a thick keratin coat beneath which papillary projections covered by cornifying epithelium become more conspicuous and pigmentation of the part is increased.

Such a stage of arrested development and regression was represented in the lesions removed from case 5. The process of healing consists in the gradual disappearance of acute exudate (and undoubtedly of most treponemata) from the margins of the yaw. The epidermis becomes again compact and reassumes the differentiation of its cells, so that there are hyperkeratosis and increased pigmentation corresponding to the degree of epidermal hyperplasia present. Coincidently, there is a thickening of connective tissue within the papillæ, surrounding the blood vessels with a compact mantle of collagen fibrils. More gradually the exudate of the corium is removed so that with complete healing the surfaces become flat, but still a little rough and thickened. There is rarely complete ulceration of the surface with destruction of corium; consequently, scars do not frequently follow healing.

THE EFFECT OF INTRAVENOUS INJECTION OF NEOSALVARSAN ON THE LESIONS

Within forty hours after the injection of a therapeutic dose of neosalvarsan all treponemata demonstrable by Levaditi's method disappear from the early fully developed yaw. Within this time also practically all exudation in the lesions subsides. The blood vessels of papillæ are rapidly returning to normal, and the excessive fluid, especially within the epidermis, is lost, probably more by surface evaporation than by absorption, so that the lesion shrinks in size. With the loss of exudate the epidermis

becomes more compact and transparent, and the surface, now dry, assumes a bright pink color when the superficial scab is removed. The fluid exudate and most of the leucocytes vanish, leaving only a small cluster here and there, and numerous isolated ones lying in interepithelial spaces.

Most of the elevation of the early yaw is due to the fact that the epidermis is turgid with fluid and cellular exudate, and the initial shrinking and flattening result from loss of this exudate. The fact that the early yaw remains turgid for long periods before treatment presupposes a continuous injury to the vascular bed within the elongated papillæ with resulting dilatation of veins, capillaries, and lymphatics, and a continuous outflow of fluid and cellular elements. Following the destruction of treponemata the source of this irritation is removed and the vascular channels rapidly repair. This is the first change in the inflammatory reaction. In sections from case 1, forty hours after treatment, there were found some injured veins and capillaries plugged with thick fibrinous thrombi, a condition not observed in any untreated lesion. The dilatation of the vascular bed was also less marked.

With the restoration of blood vessels exudation is suppressed and the excessive fluid present in the epidermis is rapidly removed by surface evaporation and by absorption, resulting in the formation of a dry crust. Surface epithelium, in the early stages uncornified, and leucocytic exudate, including superficial miliary abscesses, largely compose the structure of the superficial crust, as is evident in sections. The remaining leucocytes not cast off in the crust are removed in other ways. Thus we find in sections that numbers of them are degenerated and necrotic. No doubt a certain proportion die, disintegrate, and become absorbed with fluid exudate. A larger proportion, however, are carried off bodily by large mononuclear phagocytes. Shortly following treatment the large phagocytes may constitute a conspicuous element of the lesion. They are most abundant in the papillæ, where they have engulfed numbers of leucocytes; but they are to be found wandering through intercellular spaces of the epidermis picking up polymorphonuclear cells wherever they find them. Even in the deeper exudate of the corium they are likewise prominent and active. They remove the leucocytes partly by intracellular digestion in situ and by transporting them through lymphatic channels to other places. Dilated lymphatics in papillæ are sometimes filled with them, each laden with disintegrating remains.

This evident widespread injury to polymorphonuclears resulting in local disintegration and rapid phagocytosis is worthy of some comment. One would not expect the mere subsiding of the inflammatory process to result in a rapid degeneration of leucocytes without the introduction of some injurious element. The sudden death and destruction of treponemata with the liberation of hypothetical toxic products could hardly account for it, for the injury seems to be limited to polymorphonuclears and to small lymphocytes lying in the center of immature follicles in the corium, and affects the former equally, whether in the epidermis or deeper in the skin. Necrosis of them tends also to be more marked about some of the smaller blood vessels of papillæ, although conspicuous also within the epidermis. The question naturally arises whether neosalvarsan itself may not exert a selective injury upon these cells, and this seems the more-probable explanation. In the fresh yaw, with continuous acute exudate through dilated and injured vessels, conditions seem suitable for a direct action of the drug on leucocytes in the tissues.

The thought arises that such local disintegration of polymorphonuclears may be favorable to the destruction of treponemata, for it is to be noted in sections of early untreated lesions that these organisms are diminished very greatly in number in older miliary abscesses where disintegration of leucocytes is proceeding. Phagocytosis of treponemata by these cells I have not observed, but they do appear to be effective against the organisms in some degree.

With the removal of fluid and cellular exudate the epidermis becomes more compact and transparent. The yellow opacity of the untreated fresh yaw is due to its content of leucocytes, and when these disappear the surface becomes gray and semitransparent, so that the bright color of the circulating blood is rendered visible, for in the early stage of healing there is very little epithelial pigment. In the corium, aside from destruction of leucocytes and, to a lesser extent, of lymphocytes about the vascular center of immature follicles, and active phagocytosis of their remains, little is to be observed following treatment. The removal of plasma cells and other mononuclear-cell exudate is a very gradual process and is not noticeable within the periods after which lesions were removed. There seems to be a greater degree of hyalinization of plasma cells and a diminution in the œdema. Very quickly (by the seventh day after treatment) pigment-containing connective-

tissue cells become numerous throughout the portions involved by exudate. At the end of this time definite reparative changes have occurred in the epidermis. Leucocytic and fluid exudate has almost completely disappeared and the epithelium has actively reassumed its normal differentiation in direct proportion to the degree of hyperplasia. Pigment granules have been reformed in a quantity greater than normal within and about the lower cells of the stratum germinativum. Grossly, the yaw has assumed a dark slate gray color; its surface is dry and covered by a crust of keratinized epithelium. The freshly cut surface presents also a brownish tint in the corium, which is due to the presence of a golden brown granular pigment within cells there.

With loss of exudate and by rapid keratinization, with probably diminished growth, the epidermis has reassumed a degree of thinness approaching the normal, and the papillæ are lower and more compact. Thus, very rapidly the surface becomes level with the surrounding skin, leaving a circumscribed pale or deeply pigmented spot to mark the site. After healing not infrequently hairs within these areas grow rapidly and to a greater length than the normal, indicating persistence of a growth stimulus, manifested also by more or less hyperkeratosis which continues for a while. In children pigmentation often does not occur so rapidly nor to such an extent as in adults, and the healed skin remains pale or even whitish.

In the older dry yaws such as those in case 5, relatively little change is to be noted three days after treatment. There are still a few leucocytes, both polymorphonuclear and mononuclear (epithelioid type), in small clusters and distributed singly. In the one preparation which we studied there was extremely active mitosis in the stratum germinativum—much more than in the tissue removed before treatment—but this may well be an accidental variation. There was also some destruction of leucocytes and lymphocytes in the corium. These lesions, however, were already, by spontaneous healing, in the stage of increased pigmentation and hyperkeratosis, and no treponemata were demonstrated in either preparation.

From the histological structure of these older lesions one gets the impression that treponemata which must be harbored there, though difficult to demonstrate, may be less accessible to the destructive action of intravenous neosalvarsan than those in the more acute lesions. This is indicated by the connective tissue thickening about the blood vessels of the papillæ and the

more compact state of the epidermis with its active hyperkeratosis. Certainly the exchange of fluids appears much less than in the stage of continuous serous exudation. The fact that the older lesions succumb less readily to treatment than the exuding early ones is not altogether due to the established histological changes in the former. It would seem an advisable precaution to continue treatment until healing of such lesions is complete.

SUMMARY

1. *Treponema pertenue* has been demonstrated by Levaditi's method in abundance in early yaws, not only within the thickened epidermis as heretofore observed, but also within perivascular connective tissue of the papillæ.

2. The lesions studied indicate that the secondary yaw begins with a localization of treponemata, from the blood, in certain papillæ, and from such points the organisms infect the epidermis, where conditions become more favorable for their growth.

3. Within forty hours after the injection of a therapeutic dose of neosalvarsan all treponemata demonstrable by Levaditi's method had disappeared from early yaws.

4. The remarkably rapid healing of secondary cutaneous lesions after injection of neosalvarsan consists essentially in an almost immediate suppression of acute exudation, and the removal of excessive fluid and cellular exudate by surface evaporation, by absorption, and by phagocytosis. The thickened epidermis quickly resumes normal differentiation with hyperkeratosis for a while until the epithelial layer becomes again of normal width and rapidity of growth.

5. It seems probable that neosalvarsan is destructive of polymorphonuclear leucocytes in the lesions, and this may favor the rapid disintegration of treponemata.

6. The older secondary nodular lesions have a more-permanent architecture, heal less rapidly, and probably offer greater protection to treponemata; consequently, they require more care in effecting a complete cure.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Camera lucida sketch showing treponemata in œdematous connective tissue about vessel in a papilla.

2. Leucocytic infiltration of epithelium in an early yaw before treatment.

3. Focus of leucocytes in epithelium and treponemata.

PLATE 2

FIG. 1. Early yaw in case 2 before treatment. Same magnification, 1 to 5.

2. Yaw from case 2 three days after injection of neosalvarsan, showing scab, disappearance of exudate, and increased compactness of epithelium.

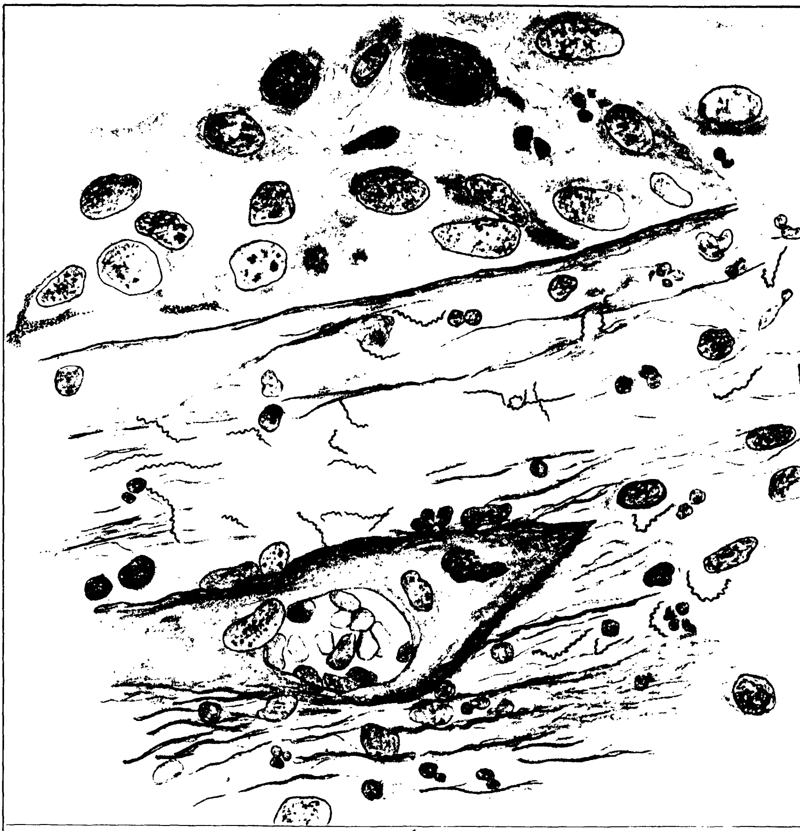
3. Yaw from case 2 nine days after injection of neosalvarsan, showing hyperkeratosis and thinning of epithelial layer.

4. Early yaw from case 1 before treatment. Leucocytic infiltration and swelling of epithelial layer.

5. Yaw from case 1 forty hours after injection of neosalvarsan. Exudate disappearing, epithelial layer more compact and thinner.

6. Necrosis of polymorphonuclear leucocytes about vessels in the epidermis forty hours after injection of neosalvarsan.

7. Same as fig. 6, showing necrosis and phagocytosis of leucocytes.



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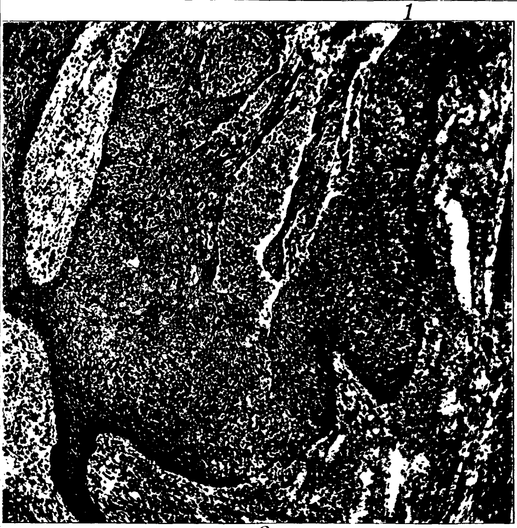

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PLATE 1.

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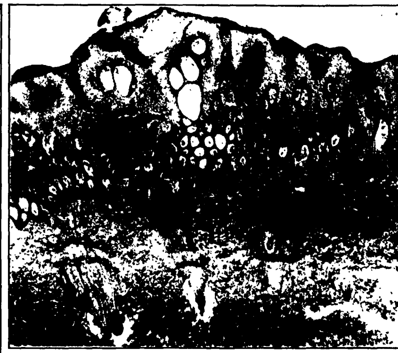

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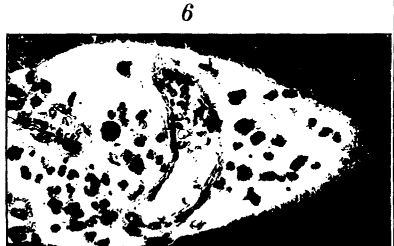

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PLATE 2.

SUMMARY CONCERNING THE CONTROL OF YAWS

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It is rather instructive to attempt to classify the important diseases of man, especially those of infectious origin, into two groups, one comprising the diseases that are eradicable or controllable by artificial means, and the other those that are non-eradicable. A disappointingly large number fall, at present, into the latter class. There are two very distinct and equally important groups of requirements for successful artificial control; one comprises the psychological factors and the other the scientific data. Operations based solely upon scientific data, even though very precise and complete, are beset with great difficulties and are foredoomed to partial failure. The information concerning the life cycle of a given parasite may be complete, and the measure for breaking this cycle may be very simple; but these facts do not offset the disadvantage of extreme indifference on the part of the infected individual.

From a psychological standpoint the disease it is proposed to eradicate must be instinctively very objectionable to the patient. In addition to this, the effective measures for its control must be of a nature that will appeal to all of the people concerned or, at the very least, be inoffensive to them. The spontaneous and hearty coöperation of the population is an invaluable asset.

In commencing the education of a community in public-health measures, much attention has been directed toward securing immediate spectacular results for the initial work. There is no disease which fulfills this condition so abundantly as yaws. It is the one infectious disease of man in which the striking benefit of therapy is just as evident to the casual onlooker as to the patient himself.

Yaws also amply fulfills the requirements of obnoxiousness, particularly as regards the loathsome lesions that develop around the mucocutaneous orifices. A single visit to a yaws clinic would surprise the most disinterested observer. The serious consequences of yaws are by no means limited to the granulomatous stage, for the late and tertiary stages produce marked pain and incapacitation. In the Loyalty Islands, Collin(2) reports that yaws is a grave menace; that in some villages of Lifou Island more than half of the children are covered with granulomata. Collin attributes the high infantile mortality of those islands to yaws and the other infections induced by it; he considers that Lifou itself is in danger of depopulation.

Left untreated, the granulomatous stage heals of itself after a few years; the mutilating tertiary lesions have been described from Africa by Howard.(3) The destructive lesions of the nasopharynx, known in Guam as gangosa, are generally considered to be a direct sequel of yaws. In Santo Domingo, the dread of yaws was particularly pronounced. Except for the intentional exposure of infants, people infected with yaws were studiously avoided. They were barred absolutely from the villages, not by government regulations, but by native custom. The first patient injected at our clinic there returned on his second visit practically cured. His first question was significant, being, "How soon may I enter the village?" Within the home, a small outbuilding was erected where the patient lived during the entire granulomatous stage, not being permitted in any of the other buildings. This primitive quarantine was apparently of some value in checking the spread of the disease within the family. These measures are certainly not practiced in the Philippines. Nevertheless, yaws patients do not mingle freely with the public. One may visit homes in villages where yaws is abundant without seeing any cases until inquiry or search is instituted, or until the opportunity for treatment is offered.

The requirement of coöperation could hardly be more readily satisfied than in the case of yaws patients. Indeed, in the early days of a clinic it is often oversatisfied. On commencing the work at Las Piñas, near Manila, we left a request for four patients to come to the Presidencia, only for examination and not for treatment. Before the appointed time, eleven presented themselves, and they brought a written list of seventeen others who requested that they be allowed to come. On some occa-

sions when no neosalvarsan was available, a few patients were requested to return later for examination only, and it was definitely announced to the other patients present that absolutely no treatments would be given and that they must not come to the next clinic. Nevertheless, they came in numbers, quietly and uncomplainingly, on the chance that some injections might be given.

In Santo Domingo we expected that the extremely superstitious people in the district where we worked, unaccustomed to medical attention, would be instinctively opposed to intravenous procedures. On the contrary, they referred to it as magic. Their confidence in the treatment was easily obtained. Patients accepted at the clinic for treatment were divided into two groups; namely, those who had just received their injections, and those who were awaiting their turn. The former at once designated themselves as the "cured cases." Occasionally a patient would present himself with nothing more than a malarial infection. Such patients, on being freely reassured and given quinine to take by mouth, often went home extremely disappointed at being denied an intravenous injection.

The acumen of the wholly untrained natives in the accurate recognition of the granulomatous stages of yaws facilitates field operations to a remarkable degree. They seldom overlook a case, and they do not tend to confuse it with other conditions. Nevertheless, it is urged that the equipment and personnel of a dispensary should not, as a general rule, be reduced to the barest working minimum. By the simple addition of a Wassermann outfit, contributions of value can be made to our knowledge of yaws and related diseases. It is well to be prepared to study some of the obscure conditions that exist in the isolated districts into which the treatment of yaws leads medical workers.

In the eradication of a disease, a distinct advantage is offered in those infections which are of the acute self-limited type and which produce a substantial immunity. This is illustrated very well by two diseases transmitted by mosquitoes; namely, yellow fever and malaria. The former has been eliminated in many regions and is even tending to die out spontaneously in some of its endemic zones. In the same geographical areas, the expenditure of considerable effort has brought malaria only under imperfect control. The lack of immunity results in the production of many chronic cases, and these serve as reservoirs of the infecting agent. However, chronicity of

an infectious disease is not necessarily a serious obstacle in attempting its control; the development of immunity is much more important, being in many cases almost an essential factor. This desideratum of immunity is at least partially fullfilled in yaws. The tendency to recurrence or reinfection after treatment is not great, amounting to about 5 per cent in practical work. Moreover, we have experimental evidence that the long-standing cases develop sufficient immunity to afford some degree of protection.

Clinically, it would seem that a certain proportion of yaws cases could be put, at least tentatively, in the rather unusual classification of a chronic self-limited disease.

A yaws clinic affords a distinct opportunity in the field of public-health nursing. The self-evident characteristics of the disease and its mode of attacking a community provide a clear, graphic illustration of the elementary precautions essential in personal hygiene. The enthusiastic coöperation of the patients makes them anxious to carry out any practical recommendations. The experience of having once had yaws teaches them the consequences of neglect and becomes an object lesson not easily forgotten.

In conclusion, we have no hesitancy in selecting yaws, without reservation, as the one outstanding disease of the Tropics through which the immediate confidence and enthusiasm of the people can be secured in public-health work. It fulfills in very fair measure the varied psychological and scientific requirements essential for the control of an infectious disease.

It seems reasonable to suppose that systematic effort, sustained over a period of a few years, would accomplish even the eradication of yaws from a given locality. There are many more or less isolated regions or individual islands in the Philippines where the feasibility of eradication could be tested experimentally.

Lastly, one's understanding of the two treponemal diseases cannot be completed by a study of either yaws or syphilis alone. Efforts in the control of yaws may properly be regarded as a step in the direction of that infinitely more-difficult problem, the control of syphilis.

ACKNOWLEDGMENTS

It is a pleasure to thank Commander Reynolds Hayden, United States Navy, for the opportunity of coöperating in the work on yaws in Santo Domingo. This work was greatly facil-

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We are very much indebted to Dr. Walter T. Swingle, of the Department of Agriculture, Washington, D. C., for photostatic reproductions of some of the inaccessible literature on yaws. For the work in Manila we received generous assistance from the H. A. Metz Laboratories of New York City.

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WOODS OF THE PHILIPPINE DIPTEROCARPS *

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THIRTY-ONE PLATES

INTRODUCTION

Previous to American occupation of the Philippines, in 1898, dipterocarps and dipterocarp forests were little known in the Islands. Under the Spanish régime timber exploitation had been largely confined to certain of the more-durable species of other families, such as narra (*Pterocarpus* spp.), tindalo [*Pahudia rhomboidea* (Blanco) Prain], molave (*Vitex parviflora* Jussieu), and others of the scarce but valuable woods, a fact which was the logical outcome of conditions then prevailing. In those days durable hardwoods were comparatively abundant and easy of access in open places near the towns. Modern sawmills were unknown, and logs were of necessity converted into lumber with the expenditure of excessive man and animal power, employed under primitive conditions. Finally, only the more durable of the native woods seemed worthy of exploitation, since consumption was confined to the Islands where deterioration, particularly that resulting from insects and fungi, is very rapid. As a result the heavier and most durable of the dipterocarps, such as yakál (*Hopea* spp., *Shorea* spp., and *Isoptera* sp.), giho [1] [*Shorea guiso* (Blanco) Blume], and manggachapuí (*Hopea acuminata* Merrill and other species) found their way into the local markets, while such of the lighter lauaans [2] as were lumbered were used mainly for canoes and dugouts or, occasionally, as floats for the heavier woods.

* Contribution from the New York State College of Forestry, Syracuse University, Syracuse, New York.

[1] This word is often written "guijo." The phonetic method of spelling is used throughout this work and an effort made to write the names as they are pronounced by the natives.

[2] The term "lauaan" was corrupted into "lauan" by the Spaniards, and subsequently adopted by the Bureau of Forestry under the American administration. Its meaning is not well understood, although the word seems to be closely related to "laua" or "laua-laua," meaning soot. When used alone, lauaan signifies any soft, light dipterocarp of the genus *Shorea*, *Parashorea*, or *Pentacme*.

With the arrival of the Americans the Bureau of Forestry was again revived. This resulted in an immediate and general inventory of the forest resources of the Islands and the enactment of measures which were intended to stop unnecessary timber destruction by land squatters and kaiñgin makers.[3] Whitford[4] in 1909 pointed out for the first time that the real forest wealth of the Philippine Islands lies in their dipterocarp forests, which make up about 75 per cent of the standing timber. Following the publication of his studies several sawmills of modern type were established, and at the present writing there are no less than twelve modern plants, each with a daily capacity ranging from 25,000 to 100,000 board feet. As a result the Philippine market has been flooded with woods that were little or wholly unknown before. Importation of structural timber from Australia and the United States has decreased, and to-day appreciable quantities of Philippine lumber are being exported to the United States and our neighboring countries.[5]

PURPOSE OF THE STUDY

Much confusion has arisen in the utilization of native dipterocarp woods owing to their sudden influx into the lumber markets of the world. Dipterocarp timbers intergrade but present wide extremes in strength, durability, beauty, and figure of grain, and it follows that some are more desirable than others, at least for special purposes. It is out of the question to expect the ordinary lumber grader or dealer to distinguish the wood of closely related species. In fact, errors of substitution are often pardonable or justifiable in that the structural variation is so slight as to have little or no bearing on the mode of utilization.[6] Few lumbermen, for instance, know the difference between red lauaan and tangile, or giho and yakál, or manggachapuí and palosapis, to say nothing of the numerous

[3] A "kaiñgin" is a temporary clearing in the forest used for crop production by the natives. The trees are felled, allowed to dry, and subsequently burned during the dry season. The kaiñgin system is largely responsible for the extensive grasslands that are found throughout the entire Archipelago.

[4] Whitford, H. N., The composition and volume of the dipterocarp forests of the Philippines, Philip. Journ. Sci. § C 4 (1909) 699–725.

[5] See P. I. Bur. Customs 1913 et seq.

[6] The lumber of tangile and red lauaan, which are among the most important dipterocarps, is often mixed indiscriminately and marketed under the trade name of "tangile."

species of lauaans. But in the inventory and development of the natural resources of the Islands, finer distinctions must be drawn. Woods which superficially seem alike may prove to differ widely in their physical properties, when more thoroughly studied. Closer utilization entails an accurate knowledge of the anatomical features and physical properties of the wood of the various forms. The following studies, based on gross and minute anatomy, aim to distinguish the commercial species. This has never been attempted previously, and the present work is in the nature of a preliminary survey.

In approaching the subject it has seemed desirable first to discuss the wood of a typical dipterocarp at some length, since this would not only acquaint the reader with the general features of the timbers of this family, but at the same time would offer a logical starting point for the rpmainder of the study. For the purpose in view, it was thought that *Parashorea malaanonan* (Blanco) Merrill[7] (*Parashorea plicata* Brandis) would best serve, owing to its wide distribution and abundance throughout the Islands and the fact that its wood seems to incorporate best

[7] Bagtikan (*Parashorea malaanonan* Merrill) (Plates 1, 2, 6, 7, 8, 22) is one of the largest of the dipterocarps and is found on all the large islands of the Archipelago from northern Luzon to Mindanao. In virgin forest it is not uncommon to find trees 40 to 50 meters in height with a diameter at breast height of 2 meters. As is characteristic for the trees of this family, the bole is tall and often unbranched for 20 or 30 meters and bears the crown far aloft. Under forest conditions the latter becomes much restricted.

Parashorea malaanonan is one of the faster-growing dipterocarps and, as is often the case in such trees, avoids habitats like the western part of Luzon, where there is a pronounced dry season. It undergoes suppression well, but the growth is then much restricted. According to Brown and Matthews, Philip. Journ. Sci. § A 9 (1914) 475, those trees which grow in dense forests undergo a long suppression period in contrast to those which are exposed, and require fully twice the time to reach any diameter up to 65 centimeters. Trees 20 centimeters in diameter average twenty-three years of age when grown in the open, while forest-grown specimens of like diameter average approximately one hundred six years.

Further researches have also shown that bagtikan exhibits periodical fluctuations of growth intensity. There are two distinct periods of slow and two of rapid growth. The first period of inhibited growth occurs during the height of the dry season when transpiration is at a maximum, the second during the mid-rainy season when the sky is overcast during a large portion of the day. The first optimum is attained during the earlier part of the rainy season and is followed by a second after the close of the rainy season when insolation is at a maximum.

those anatomical features which may be considered as typically dipterocarp. Furthermore, *Parashorea malaanonan* has been the subject of numerous studies of growth and management in the Archipelago, and a detailed study of its anatomical structure may help to solve problems of its utilization.

The remainder of the present study consists in a detailed enumeration of the gross and minute anatomical features and physical properties of the wood of the other commercial dipterocarps,[8] employing *Parashorea* as a foundation for the technical discussion. The anatomical departures will be noted at length, and it is hoped that the keys which accompany the study will prove of diagnostic and practical value.

I take this opportunity to express my sincere gratitude to Dr. H. P. Brown, head of the department of wood technology at the New York State College of Forestry at Syracuse University, Syracuse, New York, under whose department this piece of work was performed. Doctor Brown tendered invaluable advice and criticisms throughout its preparation.

ANATOMY OF THE WOOD OF PARASHOREA MALAANONAN (BLANCO) MERRILL

GROSS FEATURES OF PARASHOREA WOOD

The wood of *Parashorea* is numbered among those of the softer dipterocarps and is moderately hard and moderately heavy (specific gravity, 0.594).[9] The sapwood, which is narrow and seldom over 2 to 3 centimeters in thickness, is grayish white when first exposed, but often assumes a dark brown hue[10] in striking contrast to the paler, reddish brown heartwood.

[8] Seventy-two species of Philippine dipterocarps are known to date, grouped in nine genera. Of these, some twelve may be considered as strictly commercial species and about an equal number are of more or less importance locally. See Foxworthy, F. W., The Philippine Dipterocarpaceae, Philip. Journ. Sci. § C 6 (1911) 231; 13 (1918) 163.

[9] Determination based on mature trees from different localities; wood with moisture content of approximately 8 per cent.

[10] The darkening of the sapwood of *Parashorea* upon exposure to the air is due to certain chemical (oxidative) processes which take place in the wood. The vertical and ray parenchyma cells remain living as long as they are a part of the sapwood, and contain varying amounts of organic material. When a tree is felled and optimum conditions of temperature and humidity prevail the enzymes which are present in these living cells bring about chemical changes in their contents with a resultant darkening of the tissue. See Baily, I. W., Bot. Gaz. 50 (1910) 142–147.

Seasonal rings are wholly wanting in spite of the fact that growth intensity in the tree is known to fluctuate appreciably at different seasons. The wood is very homogeneous, of coarse even texture, and distinctly cross grained.

In cross section the vessels appear as large pores, which either are solitary or exhibit a tendency to group themselves in rounded clusters of three to six or string out in rows of three to fifteen obliquely to the wood rays. In the main the ducts are open, but occasionally tyloses are present, which occlude the vessels as reddish cystlike ingrowths. The most conspicuous feature of the section, however, and one which is of diagnostic value for all dipterocarps, is the presence of resin cysts, which in this species are filled with a white amorphous deposit and stand out as white dots against the darker opaque background of woody tissue. The resin cysts of *Parashorea* exhibit the same arrangement as the traumatic resin cysts of conifers; that is, they occur in single rows, which extend tangentially as arcs, concentric with the growth rings.[11] The radial arrangement of the rows is irregular; they occur at intervals varying from a few millimeters to several centimeters. Isolated cysts are commonly present, but they are smaller and not readily discernible with a hand lens. Tetragonal crystals of calcium oxalate may be seen with the help of a magnifier as occasional whitish dots bordering wood rays. When viewed with the naked eye, in addition to the pores the wood rays may be seen as rather fine reddish lines which extend radially through the wood. Their color is traceable under higher magnification to infiltration products contained in the ray cells. Only the larger rays are discernible at this magnification; narrow rays, too small to be visible, are interspersed between the larger ones.

The remainder of the cross-sectional area is occupied by wood elements too small to be discerned individually at low magnification. Evidence of a division of labor is to be seen, however, in that the pores are surrounded by lighter areas of tissue which had at least some part in the transportation of water and solutes while included in the sapwood. The darker areas, at some distance from the vessels, are composed of cells that perform purely the mechanical function.

In tangential section the vessels are conspicuous, owing to their large size, and appear as articulated tubes, occluded in part

[11] Complete rings of resin ducts are very rare in the dipterocarps, if they exist at all.

by reddish tylosic growths. The vessel segments, which arise from separate initials in the lateral meristem, are distinct and when viewed with a hand lens are seen to be clothed with smaller cells of similar length, the so-called tracheids. The tracheids and wood parenchyma give rise to the lighter areas about the pores as seen in cross section. The wood rays appear in sectional view as fine lines not over 2 millimeters in length.

Radial sections are striking in appearance. The relatively high wood rays are now seen in surface view against the background of other tissue and stand out as ray flecks which reflect the light differently, causing the wood to be lustrous. The vessels extend vertically and appear as in the tangential section. Owing to the interlocking grain of the wood a "ribbon" figure is produced, which is sometimes more distinct than that of *Swietenia mahagoni* Linnæus. This feature of the dipterocarps, as previously noted, is exploited by lumbermen, who in sawing their logs radially or nearly so not only obtain boards with enhanced figure, but at the same time reduce possible warping in seasoning to a minimum. The best ribbon effect is obtained when the wood rays are cut at an angle of 10° to 25° to the surface of the board.

MICROSCOPIC FEATURES OF PARASHOREA WOOD

Two methods of procedure are open in discussing the microscopical structure of wood. In the one case the tissue itself may first be dealt with and its several anatomical features enumerated at length, and following this the various elements that compose the wood may be obtained by maceration and their structure studied in detail. This order may often be reversed to advantage, since the structure of wood—that is, the arrangement of the cells that compose it—can best be interpreted when the intimate morphological features of its individual elements are understood in advance. It is then a comparatively simple matter to study such elements in the three planes of section and to trace their topography in the stem. It has seemed desirable here to follow the second plan.

PROSENCHYMA VERSUS PARENCHYMA

The woody elements of *Parashorea,* as is the case in all woody tissues, fall naturally into two groups—the prosenchymatous and the parenchymatous—between which no hard and fast line can be drawn. In general, prosenchyma consists of elongated, thickened, dead cells with strongly lignified walls and pits which are usually bordered. Prosenchymatous tissue performs two

functions in the economy of the plant; namely, conduction and mechanical support. On the other hand, parenchyma cells are thinner walled and less attenuated (often rectangular in section) and exhibit simple pits. While the walls often respond to lignin reactions, they are seldom as strongly lignified as those of the prosenchyma. The parenchyma cells of wood act as storage organs and function as long as they are a part of the sapwood; in addition, those composing the wood rays likewise are concerned in radial conduction.

The prosenchymatous tissue of *Parashorea* consists of vessels (tracheæ, pores, ducts), tracheids, and libriform fibers and extends vertically (longitudinally) in the wood. The parenchymatous tissue on the other hand consists, in part, of cells that have their long axes arranged vertically, the so-called vertical parenchyma, and in part of ray parenchyma which makes up the wood rays. Either type may give rise to idioblasts through intracell formation of crystals. In addition, the epithelial cells surrounding the resin cavities must be considered in the light of parenchyma, but whether they are of the same origin as the vertical parenchyma cells is open to argument, as in the case of the conifers.

ELEMENTS OF PARASHOREA WOOD

Vessels (*tracheæ, ducts, pores*).—(Plate 2, fig. 8.) The vessel segments are of a prosenchymatous nature and are the most conspicuous elements in macerated material owing to their large size. They appear as cylindrical structures with "tailed" ends, which taper abruptly from alternate corners, and vary in diameter and length, respectively, from 108 to 317 μ (average, 236) and 147 to 550 μ (average, 465). As in other woods their width is in inverse proportion to their length. A round perforation, opening out from either end, indicates the original interdependence of the segments as they occurred in vertical rows in the wood.

The walls of the vessel segments are comparatively thin, measuring from 3.6 to 7 μ in thickness, and are marked with bordered or semibordered pits, which conform to three types and owe their orientation to cells contiguous to the segment. Where tracheids abut on the radial or tangential walls, vertical or twisted bands of small, typically bordered pits result. The larger pits with vertical grouping, which at first glance appear to be simple but are in reality semibordered, indicate the position of vertical parenchyma cells which are coterminous to the

segment. Here and there the radial walls are latticelike or reticulate in appearance, owing to an aggregation of the larger, semibordered pits where a wood ray came in contact with the vessel. The ends of the segments frequently exhibit more abundant pitting, because the tips of neighboring cells (tracheids of the length of the segment) interlace in such a manner as to bring the maximum number in contact with the wall of the vessel.

Tracheids.—(Plate 2, figs. 10 and 11.) Tracheids are prosenchymatous elements whose primary function, like that of the vessels, is conduction. When isolated they appear as slender, elongated, generally twisted cells with rounded ends and lateral walls, which are abundantly equipped with numerous, small, bordered pits leading to neighboring tracheids or vessel segments. Occasionally the larger, semibordered pits similar to those of vessel segments are found on tracheid walls where the latter are contiguous to vertical parenchyma of wood rays. The tracheids of *Parashorea* measure from 352 to 800 μ (average, 420) in length and 14 to 30 μ (average, 24) in width and, as will be pointed out subsequently, arise from the same cambial initials as the vessel segments. In contrast to the latter, however, their walls are about half as thick and are comparable to those of the parenchyma cells.

Libriform or wood fibers.—(Plate 2, fig. 1.) The final type of prosenchyma in the wood of *Parashorea*, the libriform fibers,[12] are longer, thicker walled, and more attenuated than the tracheids and are to be regarded as typical mechanical elements. They measure from 1,130 to 2,390 μ (average, 1,690) in length and 14 to 31 μ (average, 22) in width, with walls 3.5 to 7.5 μ in thickness, and taper gradually from the center. As a rule, the ends are smooth but occasionally become serrated or forked where the fibers are pressed together. Owing to the mechanical nature of these cells, the pits on the vertical walls have degenerated into slitlike openings, which extend vertically in the cell wall and appear in the mature elements as more or less vestigial structures. Gummy deposits sometimes leach through such pits from contiguous parenchyma and partially occlude the lumina.

Vertical parenchyma (*wood parenchyma proper*).—(Plate 2, figs. 6 and 7.) In macerated material the vertical parenchyma

[12] Elements intermediate in form between tracheids and libriform fibers, the so-called fiber tracheids, are wanting in *Parashorea*.

cells appear as isolated rectangular or triangular elements, or in short series of three or four with tapering terminals. In the latter case the rows resemble superficially the septate fibers, but differ in their simple pitting and in the nature of their cross walls.[13] Their fibrous shape is indicative of the origin of the series in the cambium from primordial cells of the same type as give rise to vessel segments and tracheids. The features that separate the vertical parenchyma and prosenchyma arise subsequent to cell division in the lateral meristem and are a result of normal development in the maturation of the elements.

Both the end and the lateral walls of the parenchyma are abundantly provided with simple pits which vary in contour, depending on the nature of the neighboring elements, from round to ovoid or deltoid. The individual cells measure, respectively, 56 to 216 μ (average, 124) in length and 12 to 36 μ (average, 24) in width. As in the case of the vessel segments, it follows that the greater the diameter of the individual elements, the shorter the length. In *Parashorea* the lumina are commonly filled with gummy infiltration products.

Epithelial cells.—(Plate 2, figs. 4 and 5.) The epithelial cells are found in immediate proximity to the resin cavities and, as in the case of coniferous trees, are undoubtedly intimately concerned in the production of resin. In macerated material they usually occur in aggregates of a half dozen or more and appear as quadrate or rectangular cells which grade off into typical wood parenchyma. Their relation to the vertical parenchyma is still further accentuated by the similarity of their walls in thickening, pitting, and in their chemical nature. In *Parashorea* they measure from 10 to 30 μ in width and from 10 to 43 μ in length.

Ray parenchyma.—(Plate 2, fig. 3.) Ray parenchyma, as the term implies, is found in the wood rays and makes up the total volume of these structures, as in all hardwoods. The ray-parenchyma cells are very similar to the vertical parenchyma in shape, and in the nature of their cell walls and in macerated material are very difficult to distinguish from the latter. Only in the case of the marginal ray cells, which assume the shape of a triangular prism, can identification be positive,[14] although

[13] The cross walls of septate fibers are thinner and differ chemically from the vertical walls, while those of the parenchyma are comparable in every respect.

[14] The "end" cells of the vertical rows of parenchyma are pyramidal.

the ray cells are somewhat larger (36 to 126 μ in length and 10 to 54 μ in height) and generally contain infiltration products in larger amount than do the vertical cells. As in the other features, the rule for cell dimensions applies; namely, cell height varies inversely to cell length.

Crystallogenous idioblasts.—(Plate 2, fig. 2, and Plate 7.) Crystallogenous idioblasts are abundant in the macerated wood of *Parashorea malaanonan* (Blanco) Merr., either as isolated cells or in short rows, and they may arise from either the vertical or the ray parenchyma, though more commonly the former. When arising from the vertical parenchyma, the cells of a vertical row become further segmented by the septa into a beadlike or catenate string of compartments, twenty-five or more in number, in each of which a solitary tetragonal crystal of calcium oxalate is formed. The new cross walls thus formed are typically parenchymatous in nature, both in pitting and in thickness, and the identity of the original parenchyma cells is completely lost. Such idioblasts are to be regarded as depository organs, and the calcium oxalate is undoubtedly a waste product in plant metabolism.[15]

The idioblasts that arise from the ray parenchyma are not so abundant nor so conspicuous in macerated material as are those of the vertical type. As in the case of the longitudinal rows they are formed through subsequent septation of ray cells into from two to five compartments, in each of which a tetragonal crystal forms. The crystals are smaller as a rule than those contained in the vertical idioblasts.

DISPOSITION OF THE ELEMENTS

The preceding paragraphs have been devoted to a study of the individual elements of *Parashorea* wood as they appear in macerated material, and indicate the wide departures in cell types that are correlated with varying function. The disposition of the different elements in the cell aggregate that we know as wood may now be studied to advantage at higher magnifications and the significance of the grouping more readily understood. In the following pages the wood of *Parashorea malaanonan* is discussed in detail as it appears in the three planes of section.

Cross section.—(Plates 3, 4, and 22.) In cross section at magnifications of 50 to 100 diameters, the vessels stand out very conspicuously, owing to their abundance and their large size, and appear as rounded pores that are sharply delimited at the margin

[15] Calcium oxalate crystals are common in the tissue of the higher plants, particularly in leaves. They stain readily with methylene blue.

by the encirling walls. As previously noted, they are either solitary and assume a more or less circular contour, or in sequence and contiguous in strings of two to five, and somewhat flattened at the points of contact.[16] The diameter varies from 72 to 317 μ, but as seen in mass the impression is that of uniform size since it is only in the groups or in an occasional solitary cyst that the dimensions are appreciably restricted. The coarse texture of the wood of *Parashorea malaanonan* is traceable to the prevailing large size of the vessels, which make up about 32 per cent of the wood volume.[17]

Here and there the pores are occluded with tyloses which are infiltrated with organic material and appear as vesiculate plugs neighboring wood rays. As pointed out by other investigators, these have their origin in the large pits that separate the ray parenchyma from the vessels, and have an important bearing on the durable qualities of the wood.[18] In *Parashorea* they arise, as a rule, from the uniseriate rays, but are not sufficiently abundant to be a conspicuous feature.

Tyloses usually occur where wood rays are contiguous to vessels and, although a conspicuous feature of heartwood, are formed while the elements are still a part of the sapwood. They are of great practical significance in the utilization of wood, since they inhibit the movement of air and moisture in the tissue, both of which are necessary for fungal growth. *Hopea plagata* (Blanco) Vidal, *Isoptera borneensis* Scheffler, and various species of *Shorea* have highly developed tyloses and are among the most-durable dipterocarp woods, while the reverse applies to *Shorea eximia* Scheffler and species of *Pentacme* and *Anisoptera*.[19]

Coursing between the pores in a radial direction and making up from 11 to 17 per cent of the wood volume [20] are bands

[16] The tendency toward grouping in oblique lines, which is to be noted with a pocket lens, is obscure at higher magnifications.

[17] The volumetric data were obtained from photomicrographs by cutting out the elements concerned and comparing their weight to the total weight.

[18] The causes underlying the formation of tyloses are not well understood, but it is generally conceded that their formation is due to heightened osmotic pressure in the parenchyma bordering vessel segments which results in the "enlargement" of the middle lamella. Cystlike structures result in the vessel cavity, which may continue their growth until the lumen is completely occluded.

[19] See Gerry, Eloise, Tyloses; their occurrence and practical significance in some American woods, Journ. Agr. Res. 1 (1914) 445–469.

[20] The ray volume varies directly as the density. See Myer, J. E., The ray volumes of the commercial woods of the United States and their significance, Journ. of Forestry, Washington, D. C. 20 (1922) 337–571.

composed of elongated cells with oblique end walls and dark brown contents and conspicuous because of their darker color. The larger rays, which are multiseriate and consist of four to six rows of cells, pursue a straight course across the field except for slight deflections where they are contiguous to or approach the larger pores. At such points they curve slightly, while the pores are somewhat flattened on the side of contact. Where vessels abut on opposite sides of the ray, the latter becomes very much restricted where it extends between them.

Interspersed between the larger bands are smaller rays which, at the start at least, consist of but a single row of cells comparable in every way to those which compose the multiseriate type. The course of the uniseriate rays across the field is much more irregular than that of the multiseriate rays, since they curve around the pores that lie in their course and are not of sufficient size to cause them to become flattened. As will be pointed out subsequently, the narrow rays of the cross section are in part uniseriate throughout their vertical length, and in part the margins of multiseriate rays which happen to be included in the plane of section. It is from the uniseriate rays that the tyloses of the vessels are mainly derived. The light areas of small cells about the pores are a feature of many tropical woods and they consist, in *Parashorea,* of tracheids and vertical parenchyma (Plate 22). The tracheids, like the vessels, are organs of conduction and mechanical support, and are strictly vasicentric. They are found only in regions contiguous to vessel walls and occur in the angles between coterminous vessels, or vessels and wood rays (Plate 3).[21] The paratracheal or vasicentric parenchyma, on the contrary, separates the libriform tissue from the vessels and tracheids and may adjoin the ducts directly or abut upon the tracheids neighboring them. It performs mainly the storage function and is in intimate connection, on the one hand, with the ray cells from which it obtains food for storage and, on the other, with the vessels direct or through the intervening tracheids into which it pours food in solution at periods of growth optima. Tracheids and vertical parenchyma together constitute from 14 to 19 per cent of the wood.

The libriform fibers (wood fibers), which are the principal mechanical elements, make up the background for the other cells, and form from 35 to 40 per cent of the volume of the

[21] In this plate the tracheids to the right of the uniseriate ray are in contact with the vessel wall above or below the plane of section.

wood. As viewed in cross section they appear as small, thick-walled elements of varying size [22] and narrow lumina, and are grouped compactly in the areas not restricted to conduction and storage. Libriform fibers arise from the same fusiform cambial initials as vessel segments and tracheids but, as they mature, they elongate and push in between one another, and thicken their walls until only a narrow lumen remains. Owing to the pressure resulting from their elongation, they assume an oblong, rounded, or polygonal form in cross section. Here and there a radial row consists of units of uniform size, indicating their common origin from one initial in the lateral meristem.

In places the intervals between wood rays are solidly banked with libriform fibers and form extensive tracts of tissue whose function is purely mechanical, but often the continuity is broken by the pores with their envelope of tracheids and parenchyma or by parenchyma alone. In the latter case the cells occur in the midst of the libriform fibers as isolated units [23] which may be identified by their thin walls, or in short tangential strings that extend out laterally from the wood rays. Here and there a cell bordering a ray enlarges somewhat and becomes modified into an idioblast, which is conspicuous owing to the angular crystal that it contains. The parenchyma of *Parashorea* is, in the main, paratracheal, but a tendency toward the diffuse condition is expressed through the invasion of the libriform tissue by individual cells or tangential strings.

As previously noted under microscopic features, the resin ducts are borne in tangential rows, which occur at intervals varying from a few millimeters to several centimeters, more rarely solitary. At higher magnifications an affinity with the larger pores is expressed, which is as yet unexplained since the rows occur in areas where the vessels are numerous and bound the resin cavities on either side. The resin cysts are intercellular spaces of schizogenous origin, as in the Coniferæ, and are embedded in strings of parenchyma connecting the wood rays. They originate in the cambium as areas of parenchymatous cells, the innermost of which separate at the middle lamella and pull apart as the tissue matures. In *Parashorea* the first

[22] The varying size is to be explained by the fact that the fibers are long-attenuate and are cut at different heights in the cross section.

[23] It follows that a living cell could not exist if totally surrounded by prosenchyma (dead) tissue. Parenchyma cells, which in cross section appear to be surrounded by libriform fibers, are in contact with ray parenchyma above or below the plane of section.

indication of the formation of a resin cavity is a fissure in the tissue, which results from the splitting of the middle lamellæ between the four cells (Plate 5, fig. 1) and the subsequent separation of the elements. The process may continue tangentially (same plate, figs. 2 and 3) until other parenchyma cells are involved and cavities of considerable extent are formed, or the mature duct may have but the four epithelial cells, in which case it is usually isolated. The resin cavities of *Parashorea* measure from 30 to 130 μ tangentially and are surrounded by from four to twenty secreting cells.

In cross section the epithelial cells bordering the cavities differ little from the surrounding parenchymatous tissue. They are somewhat arched on the distal face owing to the absence of contiguous cells on that side and a resultant lack of tissue tension but, in general, retain the tabular form of the neighboring parenchyma. Strictly speaking, the epithelium consists of but a single layer of cells which lines the resin cavity and is followed peripherally by one or more layers of parenchyma, the first of which is usually more or less transitional. The disparity in form and appearance which distinguishes the epithelium from the bordering tracheids in conifers is not evident in dipterocarp woods.

When observed in the longitudinal plane the wood of *Parashorea* assumes a very different aspect, since the vertical elements are now seen from the side and features appear which are not evident in the transverse section. These may now be discussed to advantage and should serve, when considered in connection with those of the cross section, to render comprehensible the microscopic structure of *Parashorea* wood. Two sorts of longitudinal section are possible; namely, one parallel to the wood rays, known as the radial section, and one at right angles to the rays and tangent to the growth rings, the tangential.

Radial section.—(Plate 6.) In thin radial section the composite character of the vessels is readily apparent, since they appear as interstices or, where the radial walls chance to be included, as punctate fields in the tissue which are bounded laterally by articulated walls and extend longitudinally in the wood. Constrictions occur at intervals and delimit the various segments, which vary appreciably in length not only in different vessels but also, for unaccountable reasons, in the same duct. The shorter segments are wider than lông and are often barrel-shaped, while the other extreme is represented by the long cylindrical form. All grada-

tions between these types occur, since the rule covering cell dimensions likewise applies in this instance: vessel-segment width is inversely proportional to vessel-segment length. Where the section is not median to the duct, cross walls appear to separate segments owing to the constriction of the latter in the region of the pores, an illusion which is readily apparent, however, when thicker sections are prepared.

As previously pointed out, the light areas that bound the vessels laterally consist of tracheids and parenchyma or parenchyma alone. The characters of these two types of cells are now seen to better advantage, and they can be separated without any trouble. The parenchyma, which is always associated with the vessels, appears as rectangular cells several times longer than wide, but much shorter than the neighboring vessel segment. The tracheids, where present, are contiguous to the duct, are much longer than the parenchyma cells, and are characterized by rounded ends. Evidence of their origin from the same cambial initials as vessel segments is to be found in the fact that they approximate the latter in length, and transition forms between the two types are not uncommonly seen at this magnification. As in the case of the vessels, the walls appear punctate from the numerous bordered pits.

Crossing the vessels at right angles are the wood rays, which appear as broad bands of muriform parenchyma consisting of many tiers of superposed cells whose lumina contain reddish brown organic material of a gummy nature or, occasionally, crystals. In *Parashorea* the rays are of the type designated as heterogeneous, since the last series of the upper and the lower margins are higher and shorter than the others, although exhibiting similar pitting and content. In addition, rows of high cells are occasionally interspersed in the ray, but as a rule the interior appears quite homogeneous, consisting of seried ranks of quadrangular cells.

Owing to the nature of secondary thickening in trees the rays pursue in general a radial course in the wood but, as previously pointed out, are deflected more or less at the vessels, particularly the uniseriate rays. Consequently, in sections that are strictly radial and of necessity median here and there to ducts, the rays are interrupted by the vessel cavities but continue again on the other side. This results in a series of ray flecks extending across the grain of the wood which have originated from one ray. Furthermore, since new rays arise in response to necessity as

the periphery of the tree increases, it follows that ray flecks may begin or run out at any point in the wood, depending on the orientation of the section.

Occasionally, a row of resin cysts may be seen running longitudinally in the wood and appearing as a series of cavities surrounded and connected by parenchyma. The first impression is that a resin duct has run out of the plane of section only to reappear at another point, but this idea can be dissipated by reference to cross sections where it is not uncommon to find masses of parenchyma in place of the so-called resin ducts. The resin cavities of *Parashorea* consist of a series of vertical cysts separated by masses of parenchyma and are comparable to the traumatic cysts of the Coniferæ.

The epithelial parenchyma bordering the resin cysts, as seen in radial section, consists of cells that are either isodiametric or but slightly elongated longitudinally and, as noted in the cross section, arch into the cavity. These are followed laterally and at the top and bottom by other cells that are elongated in the direction of the grain and grade into typical parenchyma. The tracheids which border vessel cavities are not found near the centers of resin formation.

As in the cross section the remainder of the area is occupied by extensive tracts of libriform fibers, which are so closely crowded that the contour of the individual elements cannot be followed with any accuracy. The tissue presents a striated appearance, which owes its origin to the thick walls of the libriform cells set off by the narrow lumina alternating with them, and is easily distinguishable from the portions of the wood reserved for conduction and storage. It follows that the contour and extent of the patches of mechanical tissue must of necessity vary widely, not only in different sections but in different parts of the same section, since their orientation with regard to the other elements is purely accidental in a diffuse porous wood of this type. Laterally they are margined by parenchyma bordering resin cysts and vessels, and vertically by ray flecks. In addition the regularity is broken here and there by rows of vertical parenchyma, which formation is often changed through subsequent septation into catenate strings of idioblasts. The latter are prominent owing to the size of the crystals.

Tangential section.—(Plate 8.) The tangential section departs strikingly in appearance from the radial owing to the fact that the wood rays are now seen transversely as fusiform structures with their long axes directed longitudinally. They are typ-

ically diffuse in arrangement and vary in height from ten to sixty cells and in width from one to six cells, respectively. The cells on the upper and lower edges are larger (heterogeneous) and appear cuneiform, conforming with the contour of the ray, while those in the body vary from orbicular to ovoid or polygonal and measure from 10 to 54 μ.[24] All the cells contain organic matter, which either fills the lumina or occurs as a thin layer lining the wall. The horizontal resin ducts, described by Pfeiffer in the wood rays of three of the Javanese dipterocarps,[25] are totally wanting in *Parashorea*.[26]

Aside from the vessels, the vertical elements present the same features as in the radial section and require no further discussion here. They follow a sinuate path, owing to deflections occasioned by the larger rays, in contrast to their straight course in the radial section. In addition the individual vessel segments differ in appearance in that the terminal constriction which is perforated is now seen to be slightly oblique; where a segment is seen in median section, the points of constriction are no longer opposite each other, indicating that the vessel segments arise from fusiform initials similar to those which give rise to tracheids but have reached a high stage of development.[27]

The tangential section likewise affords the best opportunity to observe the formation of tyloses. As noted previously these arise from parenchyma which is contiguous to vessels and in *Parashorea* is traceable to wood rays, more especially the uniseriate rays. The latter are abruptly deflected where vessels intercept their course, curve around them, and subsequently form tyloses along the line of contact, which in tangential sections appear as lateral cystlike structures emanating from the rays. Whether or not tylosic formation, which owes its origin to the proximity of a vessel, results in this case from tension in the ray cells is debatable, but it seems reasonable to assume that this condition exists.

[24] The cells along the lateral margins tend to be somewhat larger than those deeper within the body of the ray.

[25] Pfeiffer, J. Ph., De Waarde van Wetenschappelijk Onderzoek voor de Vaststelling van Technische Eigenschappen van Hout. Amsterdan, J. H. de Bussy (1917).

[26] I have observed horizontal resin ducts in only one of the thirty-two species of Philippine dipterocarps that I have examined. This is *Shorea mindanensis* Foxworthy, a species restricted to Mindanao and Basilan.

[27] See Jeffrey, E. C., The Anatomy of Woody Plants. University of Chicago Press (1918).

There now remains but the discussion of the minute details of pit structure and intercellular spaces to complete the present investigation. Discussion of these has purposely been left until the last since they required magnifications ranging from one to two thousand, which were wholly unnecessary for the remainder of the study. In the foregoing pages mention has been made of the kinds of pitting that characterize prosenchyma and parenchyma, namely, the bordered and the simple type, and this point should be borne in mind in order to understand more clearly the prevailing relationships. It is assumed, moreover, that the reader is familiar with the general details of structure that characterize simple and bordered pits.

The pitting of *Parashorea* is depicted in Plate 9 and exhibits a surprising range of variation in form and size, which is in part traceable to the type of element concerned and in part to the angle of vision. Throughout, the pit cavities present a punctate appearance, owing to the presence of granular organic material which, when a pit is seen in surface view, suggests perforated pit membranes as reported by Jönsson [28] in certain Leguminosæ, an illusion which is readily corrected when the pits are seen in sectional view. Whether this organic material is in the nature of a residue left behind following the disappearance of the protoplasts in the cells concerned or is of physiological significance can only be conjectured. A second striking feature is the noticeable lack of tori in the membranes of the bordered or semibordered pits, a condition that apparently holds throughout the dipterocarp family. Even where the pits are distinctly bordered and approach those of coniferous wood, the middle lamella spanning the pit cavity presents an even appearance without suggestion of thickening of any sort. *Parashorea* wood is characterized by the total absence of tori in the pit membranes.

As seen in surface view the simple pits appear as circular, oval, or polygonal areas (Plate 9, fig. 11) delimited by a simple margin which denotes the inception of the pit cavity. The shape of the latter is variable, depending upon the proximity of other pits and the type of cells neighboring the parenchyma. In ray parenchyma the simple pits may become so numerous as to present a latticelike appearance.

[28] Jönsson, B., Siebähnliche Poren in den trachealen Xylemelementen der Phanerogamen, hauptsächlich der Leguminosen, Ber. Deutsch. Bot. Ges. 10 (1892) 494–513.

In sectional view the simple pit is seen (Plate 9, fig. 12) as a thin place in the cell wall arising through the absence of secondary layers or opposite sides of the middle lamella. The secondary layers end abruptly (without arching over) causing a break in the cell wall which is spanned only by the middle lamella. The structural details of the simple pits of *Parashorea* exhibit no departures from the usual type.

The bordered pits, on the contrary, present a wide range of variation in conformity with that of the elements on which they occur. Those that are found on vessel or tracheid walls are rounded or oval in surface view with a circular or flattened orifice. Such elements, while performing the mechanical function, are primarily concerned in water conduction and elongate but little following their origin in the lateral meristem. As a result, the pits are not stretched to any great extent. Fiber tracheids and libriform fibers, on the other hand, undergo marked changes as they mature, especially in longitudinal dimension, to fit them for their mechanical rôle. Consequently the bordered pits become very much flattened and attenuated spirally, and the pit orifice is reduced to a mere slit. The pits may become so altered in libriform fibers as to appear simple (Plate 9, fig. 9).

Plate 9 (figs. 1 to 9), presents various aspects of bordered or semibordered pits in sectional view, and the several departures deserve mention here. Pits leading from tracheid to tracheid are of the type common in coniferous and dicotyledonous wood except for the absence of tori. The pit cavity is widest at the middle lamella and tapers gradually toward the cell lumina. A curious modification, however, is to be noted in the bordered pits of vessel walls, since in these the pit flares again at either orifice giving the appearance of a double dumb-bell, a condition that is observable only in cross section; in longitudinal section such pits appear as in Plate 9, fig. 3, indicating that the constriction in the pit cavity is not annular but is limited to the sides. It follows that where vessels abut on tracheids the pit cavity is constricted on the vessel side, but of normal contour in the tracheid wall. Figures 7 to 9 of this plate are sections of pits that are very much attenuated, a type common on the walls of libriform fibers.

In conclusion, mention must be made of the intercellular spaces which are characteristic features of all woody tissue and provide a means of aëration for the cells that retain living

protoplasts as long as they are a part of the sapwood. Such spaces are seen to advantage in cross section, particularly in the libriform tissue, as minute chinks at the corners where three or more cells meet or in tangential sections where wood rays and vertical elements are coterminous. Such spaces are of undoubtedly physiological significance in the life economy of trees, but are often overlooked in a study of the wood owing to their reduced size.

COMPARATIVE ANATOMY OF THE MORE-IMPORTANT DIPTEROCARP SPECIES

In the following pages are incorporated the results of an investigation into the comparative anatomy of dipterocarp woods and their microscopic features. The Philippine species have never been subjected to a comparative microscopic study, and the present paper embodies much needed anatomical and taxonomic data. I plan to supplement this information by subsequent contributions as my knowledge of the woods of this important family increases, and desire the present work to be considered only in the nature of a preliminary survey.

GROSS FEATURES OF DIPTEROCARP WOODS

To one whose studies have been confined to the timbers of the Temperate Zone, the most striking feature of dipterocarp wood is the absence of distinct growth rings. The annual zones so characteristic of extratropical woods are wanting, owing to the fact that dipterocarps are evergreen trees of the tropical rain forests and growth is practically continuous throughout the year. Their wood when viewed in transverse section at low magnification is seen to consist of tracheids and parenchyma, traceable to fluctuating growth intensity. The faint lines delimiting the growth rings of the diffuse porous woods of the temperate regions are wholly wanting; the wood is characteristically diffuse, but diffuse in the sense of being homogeneous.

The woods of this family are further characterized by the presence of resin cysts, a feature which is diagnostic for the group. These consist in a series of tabular cavities which extend vertically for long distances in the tree, possibly from the roots continuously to the leaves, and appear in the majority of cases as white lines, owing to the nature of their contents.

In transverse section at low magnifications they generally occur as white dots[29] arranged in uniseriate rows which extend tangentially—that is, at right angles to the wood rays—but in certain species of *Vatica, Anisoptera,* and *Dipterocarpus* the arrangement may become more or less diffuse through the interruption of the lines. The radial distribution of the rows is very variable. They occasionally become practically coterminous and a biseriate or multiseriate condition may result, while in other trees, several centimeters may intervene between neighboring series. In general, suppressed or slower-growing trees exhibit the larger number, a condition which may be traceable to restricted growth or resulting traumation.[30]

Dipterocarps, in common with other trees of the tropical and temperate regions, exhibit interlocked grain, which is occasioned through a change in the direction of the vertical elements at different points along the radii of the log and results in zones in which the fiber direction alternates. Whether these are correlated in any way with annual thickening or fluctuating growth intensity is open to conjecture, but it is known that each represents the increment accruing from several seasons. Sawyers take advantage of this alternating grain in the conversion of the timber and quarter-saw logs, not only to obtain a "ribbon grain" which enhances the figure and value of the wood, but also to obtain boards which exhibit the minimum amount of warping.

As is to be expected in a family of such wide distribution in the Oriental Region and diversified habitat, dipterocarp woods display much variation in such physical properties as color, texture, and hardness, and lend themselves to multiferous uses. A brief enumeration of some of the more-striking

[29] The resins contained in the ducts are in the liquid or semiliquid state before the trees are felled but harden into a whitish mass upon drying. In some species of *Shorea* (*S. palosapis* and *S. eximia*) the resins volatilize, leaving the ducts quite empty; in others, like *Dipterocarpus grandiflorus* they are viscous, slow-drying oils. Clover, Philip. Journ. Sci. 1 (1906) 191, states that this viscous substance contains solid resin, water, and from 25 to 40 per cent of volatile oil, and believes it is a sesquiterpene or a mixture of this class of substances.

[30] In addition horizontal resin cysts are present in a few species, but they are exceedingly minute and can only be seen at higher magnification; however, Pfeiffer, loc. cit., states that some of the Javanese species exhibit resin ducts that are visible to the naked eye.

features may not be out of place here as indicative of the extremes which may be expected.

The color ranges from light yellow which is found in all species of *Anisoptera,* and in *Hopea acuminata* Merrill, *H. pierrei* Hance, *H. philippinensis* Dyer, *Isoptera borneensis* Scheffler, and *Shorea balangeran* (Korthals) Dyer, to dark reddish brown as in *Hopea plagata* Vidal. Shades of red predominate in all species of *Dipterocarpus, Shorea polysperma* Merrill, *S. negrosensis* Foxworthy, *S. palosapis* (Blanco) Merrill, *S. teysmanniana* Dyer, and *S. guiso* (Blanco) Blume. Certain forms, such as *Balanocarpus cagayanensis* Foxworthy and *Hopea mindanensis* Foxworthy, posses wood which, when green or freshly exposed, exhibits a greenish cast or grass green streaks, the color changing to dark brown with age (oxidation) and exposure to light.

Dipterocarp wood is coarse textured as a rule, a condition which is occasioned more by the large size of the vessels than by increased dimensions of the remaining elements. In fact, the coarsest commercial timbers of the Islands belong in this family, and only a few species of the family, such as *Vatica mangachapoi* Blanco and forms of *Hopea* and *Balanocarpus,* exhibit fine texture.

Finally, a surprising range of weight, hardness, strength, and durability is to be noted in the group, which may be illustrated by reference to woods representing the two extremes. *Shorea palosapis* (Blanco) Merrill is soft and light (specific gravity, 0.340)[31] and is not, in a strict sense, a structural timber. The opposite extreme is represented by such a wood as *Hopea plagata* (specific gravity, 1.202), which is very hard and very heavy and makes an excellent structural timber. Between these extremes all variations in weight, hardness, and strength occur. Durability in contact with the soil is in general directly proportional to weight, a condition which does not always hold for woods of the temperate regions nor for those of many tropical families. The softer, lighter dipterocarps of the genera *Anisoptera, Dipterocarpus, Shorea, Pentacme,* and *Parashorea* are not durable in contact with the ground, while the harder, heavier forms, such as *Isoptera borneensis, Shorea balangeran,* and *Vatica* species, are noted for their lasting qualities.

[31] Specific gravity determinations were made on mature woods (heartwood) with moisture content varying from 6 to 8 per cent.

MICROSCOPIC FEATURES OF DIPTEROCARP WOODS

The elements which make up dipterocarp wood, aside from the fiber tracheids,[32] have been enumerated and discussed in detail in this paper, and there remains but to point out the variations as to size, number, and alignment as found in the various genera and species. Dipterocarp woods, as is the case in those of other families, exhibit many microscopic features in common; and the anatomical differences that separate genera and species and which have such an important bearing on the physical properties of the wood are traceable to fluctuations in size, number, and arrangement, rather than to kinds of elements.

The most obvious evidence of modifications in the anatomy of the various dipterocarp woods is varying texture. The latter is governed by the size of the vessels in the main, since the fibrous elements in strictly diffuse porous woods of the dipterocarp type are too small to have their fluctuations in dimensions count for much in terms of texture. In discussing the vessels of dipterocarps it has seemed advisable to adopt an arbitrary classification governed largely by the magnitude of variation in the diameter of the average pore, and the following groups were finally evolved as the study developed.

Vessels	μ
Very small	50–100
Small	100–150
Medium	150–200
Large	200–250
Very large	250–400

Vatica mangachapoi and *Hopea plagata* are representative of the lower extreme and possess pores that average less than 100 μ in diameter. They are accordingly to be considered as very fine textured and in addition are hard and heavy as well. *Shorea negrosensis* and *Shorea eximia* typify the other extreme and possess pores that average over 250 μ in diameter; they are among the coarsest of the Philippine dipterocarps. Between these two extremes all gradations occur, a feature which is responsible, at least in part, for the wide utility of the woods of this family.

[32] Fiber tracheids, as the term implies, are intermediate in type between tracheids and libriform fibers and are wholly wanting in *Parashorea* wood. They are longer than tracheids but still retain the bordered pit which, however, is reduced in size and often somewhat attenuated.

While dipterocarp woods are diffuse, and diffuse in the sense of being homogeneous in that the annual zones of extra-tropical woods are lacking, they nevertheless exhibit minor variations in pore alignment. For example, the vessels of *Anisoptera, Dipterocarpus,* and *Vatica* are predominately solitary and show little tendency toward grouping, while the majority of the members of this family are characterized by groups of three or more (as high as fifteen in certain species) which are contiguous in short rows, or string out obliquely to the wood rays, a condition that is typified by *Parashorea.*

Tylosic ingrowths are always present and arise in the same manner as do those of temperate-region woods; namely, from pits leading to parenchyma proximate to the vessels. They vary in prominence and are most copiously developed in the harder and heavier species where they often completely occlude the pores. *Shorea balangeran, Isoptera borneensis, Hopea plagata,* and *Vatica* are striking examples. On the other hand tyloses are usually sparsely developed in the softer, lighter species of the genera *Shorea, Pentacme, Parashorea, Dipterocarpus,* and *Anisoptera,* the woods of which are among the most perishable of the dipterocarps.[33]

The structure of the individual tyloses varies somewhat in the different species and deserves mention here. In the majority of cases it takes the form of a thin-walled, more or less globose cyst, which at low magnifications is somewhat iridescent. Where several such cysts originate about the wall of the vessel at nearly the same height crowding ensues, resulting in forms of irregular shape, and the vessel becomes solidly packed at that point. As a rule the wall of the tylosis is thin and cellulosic in character but may, in some species, as *Vatica mangachapoi* Blanco, become more or less thickened, lignified, and provided with simple pits. As has been pointed out by other workers, the presence of tyloses is indicative of increased durability, since they inhibit the movement of air and moisture in the wood, thus restricting fungal growth.[34]

[33] In species of *Dipterocarpus* although tyloses frequently occur in the pores they do not completely block the passage of air and liquids, as may be seen by blowing smoke through a section of wood. This fact is undoubtedly responsible for the facility with which wood of *Dipterocarpus* species takes preservative treatment.

[34] This is true of the majority of dipterocarps, but it does not seem to hold good in the case of *Pentacme contorta* and *Dipterocarpus grandiflorus. Pentacme* has a more highly developed tylosis, but *Dipterocarpus* is the more durable of the two.

Tracheids are present in the majority of the dipterocarp woods and exhibit the same appearance and disposition as in *Parashorea.* They vary in number from several to a dozen or more and are always confined to the immediate vicinity of the vessels where, in conjunction with the vasicentric parenchyma, they form areas of lighter tissue about the pores.

Among the species examined tracheids are most numerous in *Parashorea malaanonan* and *Isoptera borneensis,* where as many as thirty are sometimes present in a group. The opposite extreme is found in *Vatica, Balanocarpus,* and species of *Hopea,* in which tracheids are conspicuous by their absence. The same applies to *Anisoptera* and *Dipterocarpus,* but in these genera the tracheids are replaced by an intermediate type of element, the fiber tracheid (see footnote 32). The transition from tracheids to libriform fibers is always abrupt, since vertical parenchyma usually intervenes; fiber tracheids, on the contrary, usually grade into libriform fibers gradually.

The libriform fibers make up the background of the wood; they represent the ultimate development of mechanical tissue and consist of thick-walled, long-attenuate cells (sixty to eighty times as long as wide) which occur en masse and take very little, if any, part in the movement of solutes in the tree. Extremes of variation are found in *Hopea plagata* (15 by 1,300 μ), *Vatica* (18 by 1,340 μ), and *Balanocarpus* (18 by 1,380 μ), which represent the minimum, in contrast to *Dipterocarpus vernicifluus* (27 by 1,790 μ), *Shorea teysmanniana* (31 by 1,370 μ), and other species of *Shorea, Pentacme,* and *Parashorea.* In addition a curious relation was found to exist between fibers and pores; in small-pored woods the fibers were invariably of more-restricted dimensions than in woods of coarser texture.

Libriform fibers fluctuate not only in dimensions-over-all in the various species, but likewise in the thickness of the cell wall. It follows obviously that the latter varies in inverse ratio to the thickness of the cell lumen and that the density of the wood is directly proportional. The relatively light and soft species of *Shorea, Pentacme,* and *Parashorea* are characterized by thin-walled libriform tissue, while the reverse applies in such hard and heavy species as *Shorea balangeran, Hopea plagata,* and *Vatica mangachapoi.*

The vertical parenchyma of dipterocarp wood is variable in the different genera and species, both in amount and in distribution. Two types are prevailingly present in all members of the family, the vasicentric and the diffuse. The former,

as the term implies, is associated with the vessels which it may bound directly but from which it is usually separated by intervening tracheids or fiber tracheids. The vasicentric parenchyma may be restricted in amount to only a few cells, but often exhibits a tendency toward extension tangentially, suggesting eyelets, or even crosses one or more wood rays. This is especially true of most species of *Shorea* and *Hopea* and of *Balanocarpus cagayanensis.*

The diffuse type may be represented by isolated cells that border wood rays or are embedded in the midst of the libriform tissue, as in *Anisoptera* and *Dipterocarpus,* but the arrangement is generally diffuse-zonate, in lines one (*Hopea plagata*) or more (*Isoptera borneensis, Hopea mindanensis*) cells in thickness which connect the wood rays and in which the resin cysts are embedded. In fact, all gradations, from the vasicentric through the vasicentric-zonate and diffuse-zonate to the strictly diffuse type, are to be found. Vertical parenchyma is always present though seldom conspicuous in the wood of the various species.

The horizontal parenchyma of dipterocarp wood is confined to the wood rays which vary appreciably in size and abundance, not only in the wood of the different species of dipterocarps but in different samples of the same species. *Dipterocarpus, Anisoptera,* and numerous species of *Shorea, Pentacme,* and *Parashorea* are characterized by large rays (sometimes one hundred cells high by nine cells wide) which make up from 14 to 18 per cent of the volume of the wood. The other extreme is represented by the finer-textured species of *Hopea* and *Balanocarpus* where normally the rays do not exceed sixty cells in height and five in width with which a reduced ray volume may or may not be correlated. All gradations between these extremes occur, but in general the finer-textured woods are characterized by smaller rays.

The individual rays are, without exception, of the heterogeneous type with distinct marginal cells which show to best advantage in radial section. Occasional rows of similar cells are not infrequent in the body of the ray where two distinct types of arrangement are to be noted. In the majority of cases they are interpolated among the rows of normal cells throughout the body of the ray, irrespective of the margin, and present no unusual features. In *Dipterocarpus* and *Anisoptera,* to the contrary, such interspersed rows are confined to the lateral

margins of rays and appear in tangential section as large cells bounding a central core of smaller elements. The significance of the latter arrangement has not as yet been determined.

As is often the case in other tropical families, dipterocarp woods are characterized by the presence of more or less extraneous organic matter which takes the form of amorphous brown infiltrations in the lumina of the parenchyma cells. Such organic products are usually confined to the ray cells and, as seen microscopically, appear as gummy incrustations lining the walls or filling the lumina entirely and then rendering the details of pit structure obscure. Rarely is the vertical parenchyma involved, and only when the ray cells are thoroughly impregnated is there an apparent leakage into the vertical cells. Such organic infiltrations may be reserve food which was not utilized in the further growth of the tree or, on the other hand, may be by-products of metabolism which have been deposited in the ray cells. These infiltrations are very distinct in the red lauaans such as *Shorea negrosensis* and *Shorea polysperma;* in fact, these woods in part owe their color to them. The paler white lauaans, on the contrary (*Shorea mindanensis, Pentacme contorta,* and *Anisoptera* spp.), are characterized by meager organic infiltration.

Idioblasts are present in the majority of dipterocarp woods and, as previously pointed out, have their origin in parenchyma, in both the vertical and the horizontal wood rays. Such cells usually become further segmented by secondary septa into a number of compartments in each of which a tetragonal crystal of calcium oxalate is formed. Where the rows of vertical parenchyma are involved, catenate strings result which stand out in section against the remaining tissue; on the other hand, it is not uncommon to find all the cells of a wood ray modified into idioblasts.

Idioblasts are of some diagnostic value owing to their varying distribution in the different species, a feature that has been employed to advantage in the following keys. For example, both kinds are present in *Parashorea malaanonan, Hopea acuminata, H. mindanensis,* and in species of *Pentacme.* In contrast to the above, vertical idioblasts are wanting in *Vatica mangachapoi, Hopea plagata,* and a few other forms, which is also true of the horizontal idioblasts in *Isoptera borneensis, Shorea balangeran,* and *S. guiso.* Further study and examination of many samples of each species are necessary, however, to verify the value of

idioblasts in identification, as their presence and abundance are undoubtedly influenced by various factors, such as soil chemistry and root absorption.

Mention has already been made of the gross features and distribution of the resin cysts in the dipterocarp group. They arise schizogenously through the fission of parenchyma cells and are borne in series which simulate the resin canals of the conifers. In the majority of the Philippine dipterocarps the series are restricted to a vertical alignment, and the various rows of cysts are arranged in interrupted lines which extend tangentially; but in certain species the solitary arrangement prevails, either wholly (*Vatica*) or in part (*Dipterocarpus* and *Anisoptera* spp.). Horizontal resin cysts are very rarely present, having been observed in but one (*Shorea mindanensis*) of the twenty-four species examined.[35] They are confined to the wood rays and, as seen in tangential section, appear as small apertures encircled by minute epithelial cells which are in turn bordered by normal ray cells. In contrast to the conifers where normally but one duct is found in a given ray which is thereby altered in contour (fusiform), the rays of *Shorea mindanensis* sometimes include two series of cysts but the ray remains unchanged in form. The evolutionary significance of the absence of horizontal resin cysts in the Philippine dipterocarps, aside from *Shorea mindanensis*, remains to be determined.

As seen transversely, resin cysts vary little in shape and size in the various species and little diagnostic value can be attached to such variation. Isolated cavities are usually rounded, while those of the tangential rows are compressed tangentially. Size manifests itself only in relative conspicuousness and is of little value, owing to the irregular distribution of cysts. *Vatica* is characterized by small resin cavities, while the other extreme is represented by *Dipterocarpus*.

In the following pages I have handled the subject somewhat differently from other investigators in that I have made the keys to lead to well-established commercial groups rather than to natural genera, for the sole reason of making the keys conform with the classification in the trade as well as in the forestry regulations in as much as government charges on such timbers are based on these groups.

[35] Pfeiffer (footnote 25) reports horizontal resin ducts in various Javanese dipterocarps. I have also observed them in samples from Borneo and Federated Malay States.

Key to well-established commercial groups of Philippine dipterocarp woods.

1. Resin cysts diffuse, not connected by parenchyma, occurring scattered; pores often filled with whitish resin .... 2.
   Resin cysts in concentric rings, more or less connected by light bands of parenchyma; pores very seldom if ever filled with resin .... 4.
2. Wood coarse textured; vessel lumina open, visible to the naked eye; specific gravity generally not over 0.80 .... 3.
   Wood very fine textured; vessel lumina very small, not visible to the naked eye; specific gravity over 0.85 .... **Narig group.**
3. Wood pale white to yellowish, occasionally with pinkish or reddish tinge .... **Palosapis group.**
   Wood reddish to reddish brown, often with distinct odor of resin. **Apitong group.**
4. Wood coarse textured, soft to moderately hard, light to moderately heavy; specific gravity generally not over 0.60 .... **Lauaan group.**
   Wood medium to fine textured; hard to very hard, heavy to very heavy, specific gravity generally over 0.70 .... 5.
5. Wood reddish brown or with vinaceous tinge, evenly colored. **Giho** (*Shorea guiso*).
   Wood yellowish, yellowish green, or golden brown, rarely reddish with greenish concentric bands .... 6.
6. Wood yellowish, turning to golden yellow with age, fine textured; hard and heavy; specific gravity generally below 0.80.... **Manggachapui group.**
   Wood yellowish brown or occasionally reddish with a greenish tinge, variable in texture; hard to very hard, heavy to very heavy; specific gravity over 0.85 .... **Yakál group.**

THE NARIG GROUP

The narig group is the product of the genus *Vatica* which is represented in the Islands by five described species. The woods of this genus are very much alike and differ only in their minute features.

Gross features.—Sapwood light yellowish, thick, very resinous, exuding resin until thoroughly seasoned; heartwood light yellow when first exposed, turning to reddish yellow with age. Wood very fine textured and fairly straight grained, very hard, and very heavy; specific gravity, about 1.

Microscopic features.—Vessels very small (20 to 150 μ in diameter), completely occluded with tyloses; tyloses with simple pits. Tracheids and fiber tracheids absent. Libriform fibers with distinct radial arrangement, often polygonal in transverse section. Vertical parenchyma scanty, vasicentric and diffuse, easily mistaken for pores. Idioblasts present.

Remarks.—The woods of this group are seldom found in the trade, owing to their scarcity, although *Vatica* species are widely distributed throughout the Archipelago. Only one species, *Vatica mangachapoi* Blanco, is of importance.

VATICA MANGACHAPOI Blanco. NARIG. (Plate 10.)

Gross features.—Sapwood light yellowish, thick; heartwood yellowish when first exposed, turning to russet with age. Wood the finest textured of any of the dipterocarps, fairly straight grained, very hard and very heavy; specific gravity, 0.878 to 1.03.

Microscopic features.—Vessels numerous, rounded in transverse section, from 23 to 150 μ (average, 80) in diameter; tyloses numerous, sclerosed, with simple pits. Tracheids and fiber tracheids wanting. Libriform fibers radially arranged, 18 by 1,340 μ, rounded in transverse section, lumina small; wall approximately 7.5 μ thick. Vertical parenchyma vasicentric and diffuse; gummy infiltration products globular. Resin cysts diffuse, one-third to one-half the size of the pores. Idioblasts strictly horizontal,[36] very conspicuous. Wood rays straight, broad, 4 or 5 by 55 cells in transverse section, ray parenchyma filled with gummy, globular infiltrations.

Remarks.—*Vatica mangachapoi* is widely distributed throughout the Archipelago and is found from the Babuyan Islands southward to Basilan. The heartwood in contrast to the perishable sapwood is extremely durable and is largely employed for railroad ties and other purposes where strength and durability are required. This species is sometimes mistaken for the fine-textured yakâls but can easily be separated from the latter by (*a*) the diffuse character and small diameter of the pores and resin ducts, (*b*) the absence of zonate concentric parenchyma, and (*c*) by the comparatively large sapwood.

THE APITONG GROUP

The apitong group is represented in the Philippines by seventeen species, all of which are products of the genus *Dipterocarpus* and constitute about 17 per cent of the total volume of the Islands' forest resources. The woods are very similar in their gross features and are not distinguished in the market. Among the most-important species are *D. grandiflorus, D. pilosus,* and *D. vernicifluus.*

Gross features.—Sapwood grayish red when fresh, medium thick; heartwood reddish, turning to reddish brown with age. Wood hard, heavy; specific gravity, 0.587, Gardner, 0.879; resinous, straight grained. Resin cysts prominent, diffuse.

[36] Ray idioblasts are designated as horizontal to distinguish them from the idioblasts arising from the vertical parenchyma.

Microscopic features.—Vessels large (228 to 273 μ in diameter), occasionally occluded with tyloses. Tracheids wanting, as in *Anisoptera.* Fiber tracheids prominent, proximate to the vessels. Libriform fibers more regularly arranged radially than in *Anisoptera,* averaging 26 by 1,700 μ in size. Vertical parenchyma vasicentric and diffuse. Resin cysts diffuse; epithelial cells flattened. Idioblasts absent. Wood rays 3 to 5 by 40 to 50 cells in transverse section.

Remarks.—The woods of the three species of *Dipterocarpus* are so similar in their gross and minute anatomy that it seems undesirable to attempt to separate them in a key.

DIPTEROCARPUS GRANDIFLORUS Blanco. APITONG. (Plate 11.)

Gross features.—See Gross Features of the apitong group.

Microscopic features.—Vessels large, 162 to 324 μ (average, 263) in diameter, numerous, rounded ovoid or oblong in transverse section, solitary or in groups of 2 to 6; tyloses relatively few, distinct. Tracheids wanting. Fiber tracheids prominent, proximate to the pores. Libriform fibers numerous, 26 by 1,690 μ. Vertical parenchyma vasicentric and diffuse, the latter in tangential strings of 2 to 7 cells, not as prominent as in *D. vernicifluus.* Resin cysts diffuse or occasionally in groups of 2 to 4 and then in interrupted concentric rows, rounded in transverse section, epithelial cells flattened. Idioblasts wanting. Wood rays 3 by 40 cells in transverse section.

Remarks.—Used for ordinary construction and medium-grade furniture. Not durable when exposed but lasting an indefinite period when protected from moisture. In the temperate regions where termites (white ants) and fungi are less destructive, apitong will make desirable wood for railroad ties and structural timbers where a strong hardwood is required. Like other members of the genus, apitong is easily impregnated with preservatives. The wood of this species is occasionally substituted for giho, a higher grade of timber. *Dipterocarpus grandiflorus* is widely distributed in the islands from Cagayan southward to Agusan and is one of the most abundant of the dipterocarps.

DIPTEROCARPUS VERNICIFLUUS Blanco. PANAU. (Plate 12.)

Gross features.—The wood is very similar to apitong in general appearance but is of somewhat coarser texture; specific gravity, 0.699.

Microscopic features.—Vessels large, 73 to 384 μ (average, 273) in diameter, ovoid or oblong in transverse section, the

latter type predominating; tyloses rare, inconspicuous. Tracheids and fiber tracheids as in *D. grandiflorus*. Libriform fibers numerous, radially arranged; walls average 8.8 μ in thickness. Vertical parenchyma vasicentric and diffuse. Resin cysts diffuse, surrounded by several layers of vertical parenchyma. Idioblasts wanting. Wood rays 5 by 50 cells in transverse section; ray cells with infiltrations which are not so prominent as those of *Parashorea*.

Remarks.—Used for the same purposes as apitong. This species is very widely distributed in the Islands from northern Luzon southward to Basilan. It is frequently tapped for resin which is used for calking ships.

DIPTEROCARPUS LASIOPODUS Perkins. HAGAKHAK. (Plate 13.)

Gross features.—The wood, like that of *D. vernicifluus*, is scarcely to be distinguished from apitong in general appearance; specific gravity, 0.699.

Microscopic features.—Vessels large, 88 to 294 μ (average, 228) in diameter; generally more variable and of smaller average size than the two preceding species. Tracheids wanting. Fiber tracheids common, proximate to the vessels. Libriform fibers numerous, 26 by 1,620 μ, zonate and compressed at intervals, indicative of restricted growth. Vertical parenchyma and resin cysts as in *Dipterocarpus grandiflorus*. Idioblasts wanting. Wood rays 4 by 50 cells in transverse section, usually with infiltration products.

Remarks.—Used for the same purposes as apitong. Like apitong and panau, hagakhak is found in virgin forests associated with other dipterocarps. Reported from northern Luzon southward to Zamboanga and Basilan, and said to be especially abundant in Mindoro.

THE PALOSAPIS GROUP

The palosapis group comprises the five species of *Anisoptera* that are found in the Islands. The woods are practically alike in their general features and cannot be separated on superficial examination. Since this genus does not produce wood belonging to other groups, the following description applies to the genus itself.

Gross features.—Sapwood pale, white, turning to gray or brown, medium thick; heartwood pale white to yellowish when freshly cut, occasionally with pink or rose red streaks, turning pale yellow with age. Texture coarse. Pores large, conspicu-

ous, visible to the naked eye. Resin cysts diffuse or rarely in interrupted concentric rings. Grain straight or rarely crossed. Wood medium hard and medium heavy; specific gravity, 0.399, Gardner, 0.857.

Microscopic features.—Vessels large, 158 to 250 μ in diameter; tyloses inconspicuous. Tracheids absent. Fiber tracheids present as in *Dipterocarpus*. Libriform fibers without distinct radial arrangement, 22 to 28 by 1,270 to 1,930 μ. Vertical parenchyma vasicentric and diffuse, the latter very prominent. Resin cysts diffuse-rounded. Organic infiltration scarce. Idioblasts wanting.

Remarks.—Two species, *A. thurifera* and *A. curtisii*, are commonly found in the markets, both reaching large size.

Key to the common commercial species of Anisoptera.

1. Pores over 200 μ in diameter; libriform fibers slender and long, 22 by 1,600 μ; wood rays large, 6 by 100 cells.
   Palosapis (*Anisoptera thurifera*).

   Pores under 200 μ in diameter; libriform fibers stout and short, 26 by 1,270 μ; wood rays smaller, 5 by 37 cells.. Dagang (*Anisoptera curtisii*).

ANISOPTERA THURIFERA (Blanco) Blume. PALOSAPIS. (Plate 14.)

Gross features.—For color of the wood see group characteristics. When freshly cut the heartwood often shows rose green which color fades out after a few hours' exposure to the air. Wood coarse textured, fairly straight grained, moderately hard to hard, moderately heavy to heavy; specific gravity, 0.793.

Microscopic features.—Vessels large, 54 to 265 μ (average, 210) in diameter, rounded or ovoid in transverse section, diffuse; tyloses scarce. Tracheids wanting. Fiber tracheids fewer than in *Dipterocarpus*, not sharply differentiated from libriform fibers. Libriform fibers numerous, 22 by 1,600 μ, with walls 8.5 μ in thickness. Vertical parenchyma vasicentric and diffuse. Resin cysts rounded on transverse section, diffuse; epithelial cells flattened. Idioblasts wanting. Wood rays heterogeneous, attaining a maximum size of 6 by 100 cells in transverse section; organic infiltration inconspicuous.

Remarks.—Used for temporary construction and cheap furniture, but not durable in contact with the soil. The wood of this species is frequently substituted for manggachapuí (*Hopea acuminata*), a higher grade of timber, but can be distinguished from the latter by its coarser texture and larger pores which are plainly visible to the naked eye. In addition, the resin cysts of manggachapuí are arranged in concentric rings.

ANISOPTERA CURTISII Dyer. DAGANG. (Plate 15.)

Gross features:—For color of the wood see group characteristics. The wood is very similar to that of *A. thurifera* in general appearance, but is of somewhat finer texture; specific gravity, 0.707.

Microscopic features.—Vessels medium large to large, 40 to 235 μ (average, 158) in diameter, rounded or ovoid in transverse section, diffuse. Tracheids wanting. Fiber tracheids as in *A. thurifera*. Libriform fibers numerous, 26 by 1,270 μ with walls 8 μ in thickness, irregular in arrangement; stone cells with bordered pits occasionally present. Vertical parenchyma less conspicuous than in *A. thurifera*. Resin cysts rounded in transverse section, diffuse. Idioblasts wanting. Wood rays heterogeneous, smaller than in *A. thurifera*, 5 by 37 cells in transverse section.

Remarks.—Used for the same purposes as palosapis where cheapness is the prime factor rather than strength and durability. Dagang is of more-restricted distribution than *A. thurifera*, but has been reported in Luzon from Pangasinan, Nueva Ecija, Laguna, Tayabas, and Camarines, and in Negros and Polillo.

THE LAUAAN GROUP

The lauaan group is the product of the genera *Pentacme*, *Parashorea*, and *Shorea*, the woods of which are the most important source of cheap structural timber in the Islands, and constitute the real forest wealth of the Philippines. They are among the largest of the dipterocarps, attaining a height of 60 meters and a diameter of 2 meters, and supplant the pines and other conifers in the local markets. As a group, lauaans are the least durable of the dipterocarps.

Gross features.—Sapwood grayish white, medium wide, subject to blue stain; heartwood varying from pale yellow to dark red. Texture coarse to very coarse. Pores medium to very large. Resin cysts in interrupted concentric lines, or both zonate and diffuse. Grain commonly crossed. Wood soft to medium hard, light to moderately heavy; specific gravity, 0.340 to 0.720.

Microscopic features.—Vessels medium to very large, 194 to 329 μ in diameter, tyloses inconspicuous. Tracheids few, confined to the immediate vicinity of the vessels. Fiber tracheids absent or at most inconspicuous. Libriform fibers with more or less regular radial arrangement, 22 to 28 by 1,360 to 2,020 μ,

generally flattened tangentially, with wide lumina. Vertical parenchyma vasicentric, zonate or diffuse. Resin cysts compressed, inconspicuous as compared to the vessels. Idioblasts present or absent. Wood rays 3 to 9 by 35 to 90 cells in transverse section.

Remarks.—The lauaan group may be divided into two subgroups; namely, the red lauaans and the white lauaans, which are separated as follows:

1. Wood reddish brown to brick red.. **Red lauaans.**
   Wood pale yellow to light red or pinkish............................ **White lauaans.**

SUBGROUP RED LAUAANS

The red lauaans are wholly confined to the genus *Shorea*[37] and are characterized by the reddish brown or brick red color of the wood. The following key is based on the gross and minute characteristics of the wood and should assist in the separation of species.

Key to the commercial species of red lauaans.

1. Wood light red; resin cysts small, inconspicuous, empty, that is, without whitish deposits... **Mayapis** (*Shorea palosapis*).
   Wood red to dark red; resin cysts conspicuous, filled with a whitish resin .... 2.
2. Wood soft and light, specific gravity usually less than 0.5; libriform fibers over 30 μ in transverse diameter; organic infiltration in ray parenchyma uneven and generally thin.
   Tiaong (*Shorea teysmanniana*).
   Wood medium hard and medium heavy, specific gravity over 0.5; libriform fibers less than 30 μ in transverse diameter; organic infiltration in ray parenchyma copious, generally indurated...................................... 3.
3. Vessels very large, averaging over 300 μ in transverse diameter; tracheids three or four near the junctions of vessels; libriform fibers averaging 28 by 2,020 μ; specific gravity, 0.542.
   Red lauaan (*Shorea negrosensis*).
   Vessels medium, averaging less than 250 μ in transverse section; tracheids absent or at most one or two proximate to vessels; libriform fibers averaging 25 by 1,470 μ; specific gravity, 0.575.
   Tangile (*Shorea polysperma*).

SHOREA PALOSAPIS (Blanco) Merrill. MAYAPIS. (Plate 16.)

Gross features.—Sapwood light red, medium thick; heartwood darker, the color deepening with age. Wood coarse textured, generally cross grained, soft and light; specific gravity,

[37] The reverse does not apply. Various species of *Shorea* are included among the "white lauaans."

0.340 to 0.560 (average, 0.432). Resin cysts empty in contrast to the other lauaans.

Microscopic features.—Vessels large, 117 to 367 μ (average, 257) in diameter, rounded ovoid or oblong in transverse section, diffuse; tyloses relatively abundant, thin, unlignified. Tracheids very few, proximate to the vessels. Fiber tracheids wanting. Libriform fibers numerous, 26 by 1,540 μ, with walls averaging 2.93 μ in thickness, slightly depressed on the tangential side, arranged in regular radial rows. Vertical parenchyma vasicentric-zonate and diffuse, abundant about the resin cyst, with scanty infiltration. Resin cysts in interrupted concentric rings as in *Parashorea*. Horizontal and vertical idioblasts wanting. Wood rays narrow, 4 by 60 cells in transverse section, heavily impregnated with gummy infiltration but to a less extent than in *S. polysperma* and *S. negrosensis*.

Remarks.—Mayapis is not sold at present under its own name but generally as tangile or mixed with the white lauaans. It is used for house construction and medium-grade furniture, but requires protection from moisture, as it is one of the less durable of the dipterocarps. The species is widely distributed from Cagayan southward to Zamboanga, and the trees form heavy stands in some localities, as in Laguna Province and certain parts of Mindanao.

Mayapis is often mistaken for almon (*Shorea eximia*) but can be distinguished from the latter in that the resin cysts are free of resinous contents in contrast to those of *S. eximia*.

SHOREA TEYSMANNIANA Dyer. TIAONG. (Plate 17.)

Gross features.—Sapwood light red, distinct from the heartwood, rather thin; heartwood darker red than that of mayapis. Wood coarse textured, fairly straight grained, soft and homogeneous, light; specific gravity, 0.466, easily worked.

Microscopic features.—Vessels large, average 0.268 μ in diameter, rounded in transverse section, grouped or solitary; tyloses fairly common. Tracheids few, confined to the proximity of the vessels. Fiber tracheids wanting. Libriform fibers numerous, large, 31 by 1,730 μ, with walls that average 2.93 μ in thickness, arranged in regular radial rows. Vertical parenchyma vasicentric-zonate, occasionally solitary and diffuse; organic infiltration variable; in the harder grades, such as those coming from Sibuyan, the deposits are as thick as in *Shorea polysperma* but much restricted and often not conspicuous in the lighter grades. Resin cysts concentric as in *S. palosapis*.

Idioblasts wanting. Wood rays 3 or 4 by 50 cells in transverse section.

Remarks.—Tiaong is probably the softest and most homogeneous of the lauaans. The wood is not well known at present, but occasional lots reach the market from Sibuyan and are sold as genuine tangile or a high-grade red lauaan. It is not durable when exposed and should be used only for interior work where it will last for an indefinite time. This species is widely distributed in Luzon but has been reported from only one place in Mindanao (Agusan).

The wood of tiaong is very similar to mayapis in general appearance but differs in that the resin cysts contain white amorphous deposits. It can be distinguished from tangile because it is lighter and softer and has smaller and fewer resin cysts.

SHOREA NEGROSENSIS Foxworthy. RED LAUAAN. (Plate 18.)

Gross features.—Sapwood as in *Shorea teysmanniana;* heartwood red, turning to brick red, the darkest of the lauaans. Wood coarse to very coarse textured, cross grained, soft to moderately hard, light to moderately heavy; specific gravity, 0.541. Red lauaan resembles the wood of *Parashorea* but is coarser textured and more homogeneous as a rule.

Microscopic features.—Vessels very large, 176 to 426 μ (average, 329) in diameter, oblong or rarely rounded in transverse section, grouped or solitary; tyloses sparse as in *Parashorea.* Tracheids three or four near the junctions of vessels, larger than the adjoining wood parenchyma cells. Fiber tracheids wanting. Libriform fibers numerous, large, 28 by 2,020 μ, with wide lumina and walls 2.20 to 4.38 μ in thickness, depending on the density of the specimen, in regular radial series, simulating the tracheid arrangement in coniferous wood. Vertical parenchyma vasicentric and diffuse, similar to *Parashorea.* Resin cysts in interrupted concentric lines. Idioblasts wanting or sparse (none found in sections studied). Wood rays 3 or 4 by 50 cells in transverse section, heavily impregnated with gummy infiltration products.

Remarks.—Used for medium and high-grade furniture, house construction, and cabinet work. High-grade flitches are often converted into veneer and utilized in the manufacture of piano and phonograph cases. Not durable when exposed but lasts well when protected from moisture. Red lauaan closely resembles tangile and is often substituted for this wood in the market.

Typical specimens can be separated, owing to the coarser texture of the red lauaan as compared to tangile, but intergradations often occur which make identification difficult. In addition to the differences enumerated in the key (page 325), red lauaan is more susceptible to the ravages of ambrosia beetles; in fact, to such an extent that it is difficult to find a board that is free from "pinholes." Red lauaan is one of the species marketed under the trade name of "Philippine mahogany."

Shorea negrosensis is widely distributed from northern Luzon southward to Agusan and is especially abundant in Negros, where it forms heavy stands in association with *S. polysperma*, *S. eximia*, *Pentacme contorta*, and *Parashorea malaanonan*. Foxworthy states that this species is probably the most abundant of Philippine commercial timbers.[38]

SHOREA POLYSPERMA (Blanco) Merrill. TANGILE. (Plates 19 and 20.)

Gross features.—Sapwood light red, similar to red lauaan and tiaong; heartwood generally lighter [39] than red lauaan, the harder grades occasionally with a dark purplish tinge. Wood medium to coarse textured (finer than red lauaan), cross grained, soft to moderately hard, light to moderately heavy; specific gravity, 0.575.

Microscopic features.—Vessels medium to large, 191 to 294 μ (average, 226) in diameter, oblong or rarely rounded in transverse section. Tracheids less prominent than in red lauaan. Fiber tracheids wanting. Libriform fibers smaller than in red lauaan, 25 by 1,470 μ, with walls 2.5 μ in thickness, arranged in distinct radial rows. Vertical parenchyma vasicentric and diffuse as in *Parashorea*. Resin cysts distinct, in interrupted concentric lines. Idioblasts wanting. Wood rays variable; those of soft grades narrow and high (3 by 50 cells). Ray parenchyma heavily impregnated with gummy infiltration products, comparable to that of red lauaan in this respect.

Remarks.—Used for high-grade furniture, cases for musical and scientific instruments, and aëroplane propellers. According to tests conducted at the Forest Products Laboratory [40] at

[38] Foxworthy, F. W., Philippine Dipterocarpaceae, Philip. Journ. Sci. § C 6 (1911) 275.

[39] Specimens grown in western Luzon are occasionally dark red to reddish brown and are often of greater density.

[40] Heck, G. E., and Dennis, C. E., jr., Mechanical and physical properties of tangile, U. S. Forest Products Laboratory, mimeographed November 20, 1918.

Madison, Wisconsin, tangile is approximately 14 per cent greater in weight or density than true mahogany. It was also found that the "mechanical properties of tangile compare favorably with those of true mahogany." Not durable when exposed to the weather or in contact with the ground. Tangile is known by several trade names outside the Islands such as "Philippine mahogany," "tangile mahogany," and "Bataan" or "Bataan mahogany."

Shorea polysperma is one of the most abundant of the red lauaans. It occurs from Cagayan southward to Cotabato and is cut in large quantities.

SUBGROUP WHITE LAUAANS

The white lauaans, as the term implies, are characterized by pale yellow to light red or pinkish wood, and include the species of *Parashorea* and *Pentacme,* and light-colored *Shorea* species that occur in the Islands. They are the most abundant of the dipterocarps and are found throughout the Archipelago wherever this type of forest occurs. The distinguishing characteristics of the wood of the most-important members are given in the following key:

Key to the genera and species of white lauaans.

1. Wood pale yellow; pores medium, average 200 μ; horizontal and vertical resin cysts present; vertical idioblasts wanting.
   Kalunti (*Shorea mindanensis*).

   Wood not of yellowish cast; pores medium to very coarse, generally average over 200 μ; horizontal resin cysts wanting; vertical idioblasts present .... 2.
2. Wood grayish or brownish, medium hard to hard, moderately heavy; average specific gravity, 0.593; tracheids prominent, 2 to 12 in number.
   Bagtikan (*Parashorea malaanonan*).

   Wood grayish white to light red or pinkish, soft to medium hard, light to moderately heavy; specific gravity rarely over 0.55; tracheids inconspicuous, 1 to 6 in number........ 3.
3. Wood light red to pinkish or often with vinaceous tinge; pores numerous, predominately oblong; idioblasts wanting or very sparse.
   Almon (*Shorea eximia*).

   Wood grayish white; pores relatively few; vertical and horizontal idioblasts numerous........ 4.
4. Wood coarse to very coarse textured; pores large, average over 300 μ in diameter; average specific gravity, 0.555; libriform fibers narrow, 25 by 1,910 μ........ **Mindanao white lauaan** (*Pentacme mindanensis*).

   Wood medium to coarse textured; pores medium to large, average less than 300 μ in diameter; average specific gravity, 0.471; libriform fibers broad, 28 by 1,450 μ........ **White lauaan** (*Pentacme contorta*).

SHOREA MINDANENSIS Foxworthy. KALUNTI. (Plate 21.)

Gross features.—Sapwood whitish, narrow, sometimes turning to grayish brown and becoming darker than the heartwood; heartwood nearly white when fresh, turning yellowish or yellowish brown on exposure. Wood fine textured and cross grained, moderately heavy, specific gravity, 0.532.

Microscopic features.—Vessels fine to medium, 59 to 250 μ (average, 200) in diameter, terete or rounded in transverse section, solitary or in groups of 2 or 3; tyloses sparse. Tracheids few. Fiber tracheids wanting. Libriform fibers numerous, medium-sized, 21 by 1,360 μ, arranged in distinct radial series. Vertical parenchyma vasicentric and diffuse, the latter inconspicuous. Resin cysts inconspicuous in interrupted concentric lines, horizontal resin cysts present. Horizontal idioblasts common; vertical idioblasts sparse or wanting. Wood rays broad and high, 6 by 100 cells.

Remarks.—Used for cheap construction, piling, and temporary structures. Not durable when exposed or in contact with the ground. Difficult to saw in spite of its softness, even in large band mills, and hence not lumbered to any extent and not well known in the market. The only Philippine dipterocarp of those studied with horizontal resin cysts.

Shorea mindanensis is confined wholly to Mindanao, where it is relatively abundant.

PARASHOREA MALAANONAN (Blanco) Merrill. BAGTIKAN. (Plates 6, 7, 8, and 22.)

Gross features.—Sapwood white, medium thick; heartwood grayish red, often with a brownish cast. Wood coarse and uneven textured,[41] cross grained, moderately hard to hard, moderately heavy; specific gravity, 0.593.

Microscopic features.—Vessels large to very large, 73 to 317 μ (average, 275) in diameter, terete to oblong in transverse section, solitary or in groups or strings of 3 to 15; tyloses sparse. Tracheids relatively abundant, proximate to the vessels. Fiber tracheids wanting. Libriform fibers numerous, medium-sized, 22 by 1,540 μ; radial arrangement less distinct than in kalunti. Vertical parenchyma vasicentric, vasicentric-zonate, or diffuse. Resin cysts in interrupted concentric rows, rarely solitary. Horizontal and vertical idioblasts present. Wood rays broad and high, 6 by 60 to 90 cells.

[41] Bagtikan is the most uneven textured of the lauaans, owing to the irregular distribution of the vessels.

Remarks.—Used for rough construction, including siding, sheathing, and concrete forms, and for cheap furniture and dugout canoes. Not durable when exposed or in contact with the soil.

Bagtikan,[42] although cut in large quantities, is sold at present as "white lauaan." It is as a rule harder and heavier and consequently stronger than white lauaan (*Pentacme contorta*) and deserves to be marketed under its own name. The wood is distinct from the other lauaans owing to its brownish cast, its relatively greater hardness and weight, and the pronounced grouping of its vessels.

Parashorea malaanonan is widely distributed throughout the Archipelago in regions where there is no pronounced dry season. It has not been reported from the northwestern part of Luzon.

SHOREA EXIMIA (Miquel) Scheffler. ALMON. (Plate 23.)

Gross features.—Sapwood yellowish white, turning dark brown upon exposure, thin; heartwood pale red, fading to pinkish red. Wood coarse to very coarse textured, cross grained, soft to moderately hard, light to moderately heavy; specific gravity, 0.514.

Microscopic features.—Vessels large to very large, 162 to 352 μ (average, 300) in diameter, oblong in transverse section, solitary or, more rarely, grouped; tyloses sparse. Tracheids few. Fiber tracheids wanting. Libriform fibers numerous, large (27 by 1,630 μ), with walls 2.5 to 4.4 μ (average, 3.5) in thickness, with distinct radial arrangement; lumina large. Vertical parenchyma vasicentric and diffuse, the latter inconspicuous. Resin cysts in interrupted concentric lines. Horizontal and vertical idioblasts wanting or sparse. Wood rays 4 or 5 by 60 to 70 cells; organic infiltration thin.

Remarks.—Used for the same purposes as white lauaan and bagtikan, for rough construction, siding, and interior finish. Not durable when exposed, but less subject to ambrosia beetles than red lauaan.

With age almon assumes a reddish or pinkish red hue, thus rendering its separation from the red lauaans difficult except through microscopic features. Curly or mottled grades of almon are marketed as "curly bagtikan."

[42] The wood known in the market as "curly" or "birdseye" bagtikan is *Shorea eximia*.

Shorea eximia is reported from the eastern part of Luzon southward to Zamboanga, but like *Parashorea* is confined to regions where a dry season is not pronounced.

PENTACME MINDANENSIS Foxworthy. MINDANAO WHITE LAUAAN. (Plate 24.)

Gross features.—Sapwood whitish, turning pale gray in drying; medium thick; heartwood pale grayish to grayish brown. Wood coarse to very coarse textured, cross grained, soft to moderately hard, light to moderately heavy; specific gravity, 0.555. The wood is practically identical with white lauaan except for its coarser texture.

Microscopic features.—Vessels large to very large, 117 to 412 μ (average, 320) in diameter, oblong in transverse section, solitary or in groups of 2 or 3; tyloses sparse. Tracheids 1 to 6, relatively inconspicuous. Fiber tracheids wanting. Libriform fibers numerous, large (25 by 1,910 μ), radially arranged in distinct rows. Vertical parenchyma vasicentric and diffuse, the latter occasionally zonate. Resin cysts in interrupted concentric lines. Horizontal and vertical idioblasts present. Wood rays broad and relatively high, 6 or 7 by 60 cells.

Remarks.—Used for the same purposes as white lauaan and bagtikan, and in all probability identical in durability. The wood of the species is sold as white lauaan, from which it is distinguished only with difficulty.

Pentacme mindanensis is confined wholly to Mindanao, where it occurs in admixture with other dipterocarps.

PENTACME CONTORTA (Vidal) Merrill and Rolfe. WHITE LAUAAN. (Plate 25.)

Gross features.—Similar to those of Mindanao white lauaan except for the slightly finer texture and lighter weight; specific gravity, 0.471.

Microscopic features.—Vessels medium to large, 103 to 279 μ (average, 219) in diameter, terete or oblong in transverse section, solitary or in groups of 2 to 4; tyloses sparse. Tracheids few, 1 to 6, inconspicuous. Fiber tracheids wanting. Libriform fibers numerous, large (28 by 1,450 μ), in distinct radial rows, simulating the tracheids of coniferous wood; lumina broad. Vertical parenchyma vasicentric and diffuse; inconspicuous and difficult to identify in transverse section from the thin-walled libriform fibers. Resin cysts in interrupted concentric lines, inconspicuous. Horizontal and vertical idioblasts present. Wood rays varying directly according to density.

Dense specimens from western Luzon exhibit broad rays (9 by 55 cells), while in light samples they are restricted in size (4 by 45 cells).

Remarks.—This species furnishes the bulk of the white lauaan of the trade and is used extensively for rough construction, cheap furniture, and other purposes when strength and durability are not essential. The better grades are undoubtedly mixed with almon and bagtikan and reach the foreign market as "Philippine" or "white mahogany."

Pentacme contorta is widely distributed throughout the Archipelago, growing in admixture with other dipterocarps and forming heavy stands.

THE YAKÁL GROUP

The yakál group comprises the harder and heavier dipterocarps belonging to the genera *Hopea, Shorea, Balanocarpus,* and *Isoptera,* and is to be regarded as purely arbitrary. It approaches most closely the manggachapuí group but differs in the greater weight, hardness, and durability, and the darker color of its woods. The first two genera contain numerous species and are represented in other groups. Only two species of *Balanocarpus* and one of *Isoptera* are known to occur in the Philippines, and these are wholly confined to the yakál group.

Gross features.—Sapwood pale grayish white, variable in thickness; heartwood pale yellow when first exposed, turning to shades of yellow, brown, or reddish brown. In addition *Hopea mindanensis* and *Balanocarpus cagayanensis* exhibit greenish streaks which assume the form of concentric bands. Wood very fine to medium textured, straight or cross grained, hard to very hard, and heavy to very heavy; specific gravity, 0.80 to 1.20.

Microscopic features.—Vessels very small to medium, 67 to 180 μ in diameter, terete to oblong in transverse section, solitary or grouped; tyloses abundant, very conspicuous. Tracheids present or wanting. Fiber tracheids wanting. Libriform fibers numerous, thick walled, closely packed, radially or irregularly arranged. Vertical parenchyma various, vasicentric to diffuse. Resin cysts in interrupted concentric rows, relatively inconspicuous. Idioblasts present. Wood rays narrow to medium, not exceeding 5 cells. Organic infiltration variable.

Remarks.—This group comprises the hardest and most durable of the Philippine dipterocarps, and furnishes the bulk of the heavy structural timbers of the Islands.

Key to the genera and species in the yakál group.

1. Wood when freshly cut greenish or with grass green streaks................ 2.
 Wood neither greenish nor with grass green streaks when freshly cut..3.
2. Wood when freshly cut reddish, aside from the greenish streaks; pores medium (average, 159 μ); rays large, 4 by 95 cells; southern species.
 Bagususu (*Hopea mindanensis*).
 Wood when freshly cut grayish or yellowish green to grayish brown, aside from the greenish streaks; pores fine (average, 119 μ); rays small, 4 by 25 cells; northern species.
 Narek (*Balanocarpus cagayanensis*).
3. Texture very fine; pores small (average, 100 μ), indistinct to the naked eye; wood very hard and very heavy; specific gravity, 0.98 to 1.20; tracheids and vertical idioblasts wanting........ Yakál (*Hopea plagata*).
 Texture fine to medium; pores small to medium (average, over 100 μ), distinct to the naked eye; wood hard to very hard, heavy to very heavy; specific gravity, 0.80 to 1.05; tracheids and vertical idioblasts present .... 4.
4. Pores medium (average, 180 μ), conspicuously thick walled; tracheids and vertical parenchyma prominent; tyloses completely occluding the vessels.. Malayakal (*Isoptera borneensis*).
 Pores small (average not over 140 μ), not conspicuously thick walled; tracheids and vertical parenchyma not prominent; tyloses not completely occluding the vessels........................ Gisok (*Shorea balangeran*).

HOPEA MINDANENSIS Foxworthy. BAGASUSU. (Plate 29, fig. 2.)

Gross features.—Sapwood grayish white, subject to sap stain, thin; heartwood reddish brown with concentric greenish zones which turn nearly black with age. Wood fine to medium textured, fairly straight grained, very hard and very heavy; specific gravity, 0.849.

Microscopic features.—Vessels numerous, medium-sized, 37 to 191 μ (average, 159) in diameter, ovoid in transverse section, solitary or in groups of 2 or 3; tyloses numerous. Tracheids and fiber tracheids wanting. Libriform fibers numerous, small (19 by 1,566 μ), with walls 8.3 μ in thickness, radially arranged. Vertical parenchyma vasicentric- and diffuse-zonate, in tangential bands, connecting wood rays. Resin cysts in interrupted concentric lines. Horizontal and vertical idioblasts present, the last predominating. Wood rays medium (4 by 95 cells), dark colored with organic infiltration.

Remarks.—Used locally for structural timber, railroad ties, bridge construction, and other purposes where a strong and durable wood is required. Similar to narek but can be distinguished by the reddish tinge of the wood. Probably more durable than the manggachapuís although less lasting than the better-known yakáls. Easily distinguished from the other

yakáls by the greenish cast of the wood, but little known and consequently bringing a low price in the local markets.

Hopea mindanensis is reported to be fairly common in southern Mindanao, where it is lumbered in limited quantities; it is wholly confined to that island.

BALANOCARPUS CAGAYANENSIS Foxworthy. NAREK. (Plate 29, fig. 1.)

Gross features.—Sapwood pale green, thick; heartwood yellowish to dark green, with distinct concentric bands of grass green streaks. Wood very fine textured, straight grained, hard to very hard, heavy to very heavy; specific gravity, 0.833.

Microscopic features.—Vessels numerous, small, 51 to 166 μ (average, 119) in diameter, terete to oval or ovoid, solitary or in groups of 2 or 3; tyloses prominent. Tracheids and fiber tracheids wanting. Libriform fibers numerous, small (18 to 1,380 μ) with walls 6.5 μ in thickness, somewhat radially arranged. Vertical parenchyma prominent, vasicentric- to diffuse-zonate. Resin cysts in interrupted concentric lines. Horizontal and vertical idioblasts present, the latter predominating. Wood rays small (3 or 4 by 35 cells).

Remarks.—Used for house posts and permanent construction where strength and durability are required. Little known except in the local markets of northern Luzon, where it is used extensively for house posts.

Balanocarpus cagayanensis is a tree of medium size and has been reported only from Cagayan Province, Luzon.

HOPEA PLAGATA Vidal. YAKÁL. (Plate 31, fig. 2.)

Gross features.—Sapwood pale yellow when fresh, turning to dirty gray upon exposure, medium thick; heartwood pale yellow to yellowish brown. Wood very fine to fine textured, fairly straight grained, extremely hard and heavy; specific gravity, 0.99 to 1.20.

Microscopic features.—Vessels numerous, very small to small, 44 to 88 μ (average, 67) in transverse section, terete to oval or ovoid, in groups of 2 or 3; tyloses prominent, completely occluding the pores. Tracheids and fiber tracheids wanting. Libriform fibers numerous, small (13.6 by 1,360 μ), with walls 6.9 μ in thickness, radially arranged. Vertical parenchyma vasicentric and diffuse-zonate, the latter usually in tangential rows, one cell in thickness. Resin cysts in interrupted concentric lines, inconspicuous. Vertical idioblasts wanting; horizontal

idioblasts very numerous and prominent, often making up the whole ray. Wood rays small (3 by 30 to 40 cells); infiltration sparse.

Remarks.—Used for permanent construction such as houses, bridges, wharves, and railroad ties owing to its great strength and durability. Often mistaken for *Vatica* but distinguished by the concentric rows of resin cysts and diffuse-zonate parenchyma.

Hopea plagata is very widely distributed in Luzon, from Cagayan southward to Sorsogon. Also reported from Mindoro southward to Basilan.

ISOPTERA BORNEENSIS Scheffler. MALAYAKAL. (Plate 26.)

Gross features.—Sapwood light gray, medium thick; heartwood pale grayish to yellowish gray. Wood fine to medium textured, cross grained, hard to very hard, heavy to very heavy; specific gravity, 0.734?

Microscopic features.—Vessels numerous, medium sized, 44 to 250 μ (average, 180) in transverse section, rounded to oblong, thick walled, solitary or in groups of 2 to 4; tyloses very prominent, completely occluding the pores. Tracheids numerous but less so than in *Parashorea.* Fiber tracheids absent. Libriform fibers numerous, medium-sized (18 to 1,480 μ), with walls 8.3 μ in thickness, in indistinct radial rows. Vertical idioblasts present. Horizontal idioblasts wanting. Rays small (4 by 35 cells). Organic infiltration conspicuous.

Remarks.—A very strong and durable wood, and for this reason largely employed in permanent construction where strength and durability are essential. Used for the same purposes as *Hopea plagata,* and probably the source of the bulk of the yakâl timber of the market.

Isoptera borneensis is reported from Camarines, southern Luzon, southward to Samar and Mindanao, where it forms extensive stands in Zamboanga.

SHOREA BALANGERAN (Korthals) Dyer. GISOK. (Plate 27.)

Gross features.—Very similar to malayakal. Sapwood light gray, medium thick; heartwood grayish to yellowish gray. Wood fine textured, cross grained, hard to very hard, heavy to very heavy; specific gravity, 1.05.

Microscopic features.—Vessels scattered, small, 73 to 191 μ (average, 138) in diameter, rounded to oval, solitary or in groups of 2 or 3; tyloses numerous. Tracheids few, 1 or 2, proximate to vessels. Fiber tracheids wanting. Libriform fibers numerous, small (18 by 1,480 μ), with walls 7 μ in thick-

ness, arranged in distinct radial rows. Vertical parenchyma vasicentric- to diffuse-zonate. Resin cysts in interrupted concentric rows. Vertical idioblasts present. Horizontal idioblasts wanting. Wood rays small (3 or 4 by 60 cells); organic infiltration conspicuous.

Remarks.—Used for permanent construction, shipbuilding, and bridges, owing to its strength and durability. One of the best structural timbers of the Islands and obtainable in quantity in large sizes.

Shorea balangeran is reported from Luzon southward to Zamboanga and reaches the local markets in appreciable quantities.

SHOREA GUISO (Blanco) Blume. GIHO. (Plate 28.)

Gross features.—Sapwood light gray, thin; heartwood reddish brown to brown. Wood fine to medium textured; cross grained, medium hard to hard, moderately heavy to heavy; specific gravity, 0.812.

Microscopic features.—Vessels numerous, small, 64 to 205 μ (average, 137) in diameter, rounded or oblong, solitary or in groups of 2 or 3; tyloses sparse. Tracheids rare. Fiber tracheids wanting. Libriform fibers numerous, small (19 by 1,370 μ), with walls 6.4 μ in thickness, arranged in radial rows. Vertical parenchyma vasicentric to vasicentric-zonate, occasionally diffuse. Resin cysts in interrupted concentric rows. Vertical idioblasts prominent. Horizontal idioblasts wanting. Wood rays small (3 or 4 by 40 cells). Organic infiltration copious, especially in the wood rays.

Remarks.—Used for general construction, houses, and is the favorite wood for vehicle parts. Not durable when exposed or in contact with the soil. Probably the best-known dipterocarp of the Islands, not only on account of its wide distribution but also because of the general utility of the wood. Often substituted for the coarse-textured yakáls such as gisok and malayakal, from which it differs in its lighter, softer, reddish (in contrast to yellowish gray) wood. On the other hand, the apitongs are substituted for it in the market but are to be distinguished in that the various species of *Dipterocarpus* are coarse textured and exhibit diffuse resin cysts.

Shorea guiso is widely distributed throughout the Archipelago from Cagayan southward to Zamboanga.

THE MANGGACHAPUÍ GROUP

The manggachapuí group is wholly confined to the genus *Hopea* and takes its name from the best-known species, *Hopea*

acuminata. The wood resembles the finer-grained yakáls of the genera *Hopea* and *Balanocarpus,* but differs from these largely in hardness, weight, and durability.

Gross features.—Sapwood pale white, variable in thickness; heartwood pale grayish yellow turning to golden yellow or russet in contrast to the yakáls, which assume a much darker hue. Wood very fine or fine textured, straight or rarely cross grained, moderately hard to hard, moderately heavy to heavy; specific gravity, 0.680 to 0.844.

Microscopic features.—Vessels small to medium (145 to 167 μ in diameter), terete or oblong in transverse section, solitary or grouped; tyloses not abundant. Tracheids and fiber tracheids wanting. Libriform fibers numerous, variously arranged. Vertical parenchyma vasicentric to diffuse-zonate. Resin cysts in interrupted concentric lines, not conspicuous. Idioblasts present. Wood rays narrow (not exceeding 5 cells). Organic infiltration variable.

Remarks.—The manggachapuí group comprises the soft, finer-textured dipterocarps. They are neither so strong nor so durable as the yakáls, but are used locally as structural timbers where woods of moderate strength and durability are required. Not obtainable in large quantity.

Key to the species in the manggachapuí group.

1. Pores numerous, in groups of 2 to 5; vertical parenchyma prominently diffuse-zonate, forming concentric bands; trees of small or medium size with thick sapwood................ Gisok-gisok (*Hopea philippinensis*).
   Pores relatively few, solitary or in groups of 2 or 3; vertical parenchyma prominently vasicentric or inconspicuously diffuse-zonate; trees of medium or large size, with thin sapwood................ 2.
2. Libriform fibers in distinct radial rows; vertical idioblasts wanting. Manggachapuí (*Hopea acuminata*).
   Libriform fibers not radially arranged; horizontal and vertical idioblasts present, the latter predominating........ Dalingdingan (*Hopea pierrei*).

HOPEA PHILIPPINENSIS Dyer. GISOK-GISOK. (Plate 30, fig. 2.)

Gross features.—Sapwood pale white, thick; heartwood pale grayish yellow turning to russet upon drying, restricted owing to the small size of the tree. Wood fine to medium textured, straight grained, moderately hard to hard, moderately heavy to heavy; specific gravity, 0.771.

Microscopic features.—Vessels numerous, small to medium sized, 80 to 191 μ (average, 145) in diameter, terete to oblong or ovoid in transverse section, generally in groups of 2 to 5;

tyloses sparse. Tracheids and fiber tracheids wanting. Libriform fibers numerous, small (19 by 1,320 μ), irregularly arranged. Vertical parenchyma vasicentric to diffuse-zonate, the latter conspicuous. Resin cysts in interrupted concentric lines. Both horizontal and vertical idioblasts present, the vertical predominating. Wood rays medium sized (4 by 70 cells). Organic infiltration inconspicuous.

Remarks.—Used locally for posts and piling, rarely sawn into lumber owing to the small size of the trees.

Hopea philippinensis is widely distributed throughout the Islands from Laguna, southern Luzon, southward to Basilan, in regions where precipitation is evenly distributed throughout the year.

HOPEA ACUMINATA Merrill. MANGGACHAPUÍ. (Plate 30, fig. 1.)

Gross features.—Sapwood pale white, thin, susceptible to dark brown sap stain; heartwood pale grayish yellow, turning to golden brown or russet upon exposure. Wood fine to medium textured, fairly straight grained, moderately hard and heavy; specific gravity, 0.783.

Microscopic features.—Vessels scattered, small to medium sized, 103 to 191 μ (average, 167) in diameter, rounded to ovoid or oblong in transverse section. Solitary or in occasional groups of 2 or 3; tyloses sparse. Tracheids and fiber tracheids wanting. Libriform fibers numerous, small (18 by 1,290 μ), with walls 4 or 5 μ in thickness, in distinct radial rows. Vertical parenchyma vasicentric, occasionally diffuse. Resin cysts in interrupted concentric lines, not conspicuous. Horizontal idioblasts present. Vertical idioblasts wanting or inconspicuous. Wood rays small (4 by 50 cells). Organic infiltration inconspicuous.

Remarks.—Used for bridges, medium-grade furniture, and rough construction where wood of medium strength and durability will suffice. Manggachapuí is a favorite wood for door and window frames. It is one of the best-known woods for shipbuilding. Less durable than the yakáls. Supply limited.

Hopea acuminata is widely distributed throughout the Archipelago, from northern Luzon to southern Mindanao. See remarks under *Anisoptera thurifera*.

HOPEA PIERREI Hance. DALINGDIÑGAN. (Plate 31, fig. 1.)

Gross features.—Sapwood similar to that of manggachapuí; heartwood pale yellowish, turning to russet upon exposure.

Wood fine to medium textured, fairly straight grained, moderately hard to hard, moderately heavy to heavy; specific gravity, 0.793.

Microscopic features.—Vessels numerous, small, 44 to 170 μ (average, 147) in diameter, rounded to oblong in transverse section, solitary or in occasional groups of 2; tyloses sparse. Tracheids and fiber tracheids wanting. Libriform fibers numerous, small (17 by 1,370 μ), with walls 4.4 μ in thickness, in indistinct radial rows. Vertical parenchyma vasicentric but tending toward diffuse-zonate; diffuse parenchyma sparse, inconspicuous. Resin cysts in interrupted, concentric lines, inconspicuous. Horizontal and vertical idioblasts present, the latter predominating. Wood rays small (4 by 80 cells). Organic infiltration scanty.

Remarks.—Used for the same purposes as *Hopea acuminata,* which it resembles in gross characters, but separated microscopically according to the features enumerated in the key.

Hopea pierrei occurs throughout the Islands from northern Luzon to northern Mindanao, but is best known in Laguna and Tayabas Provinces, Luzon.

ILLUSTRATIONS

[The photomicrographs and drawings for Plates 2 to 31 were made by Luis J. Reyes. Etchings furnished by the Bureau of Forestry.]

PLATE 1

A typical dipterocarp forest showing the characteristic habits of trees. Most of the trees in this type of forest are red lauaan (*Shorea negrosensis*), tangile (*Shorea polysperma*), bagtikan (*Parashorea malaanonan*), and white lauaan (*Pentacme contorta*).

PLATE 2. PARASHOREA MALAANONAN, ELEMENTS OF THE WOOD; × 4,000

FIG. 1. A libriform or wood fiber. Note the great length, the thickness of the wall, and the paucity of the pits.
2. Ray or horizontal idioblasts. Note the crystals of calcium oxalate and the thin membranelike wall separating them.
3. A ray or horizontal parenchyma cell with gummy infiltration.
4. An epithelial cell as seen in cross section. Note the simple pits which show its parenchymatous origin.
5. An epithelial cell as seen in longitudinal section.
6. A string of wood or vertical parenchyma cells. Note the large pits which are present whenever these cells abut tracheids or vessels.
7. A string of wood parenchyma cells. Note the small simple pits which are present when these cells abut similar parenchymatous cells.
8. A vessel segment. Note the two types of pits which are present as in fig. 6.
9. A string of vertical idioblasts. Note the simple pits which show their parenchymatous origin.
10. A tracheid showing two kinds of pits. The large ones are pits leading from tracheids to parenchymatous cells, while the smaller ones lead from tracheids to similar tracheids or other prosenchymatous cells. (See figs. 6 and 8.)
11. A tracheid showing numerous, small, bordered pits.

PLATE 3

Parashorea wood, a cross section, showing relationship of the elements in greater detail; × 264.

PLATE 4

Parashorea wood, a cross section, showing prominent tyloses which largely inhibit the passage of air and liquids in the vessels; × 200.

PLATE 5. DIAGRAMMATIC PRESENTATION OF THE FORMATION OF RESIN CANALS, SHOWING THEIR SCHIZOGENOUS NATURE; × 270

FIG. 1. The splitting apart of four wood parenchyma cells.
2. A more-advanced stage of development, showing six epithelial cells.

FIG. 3. A typical mature resin duct, showing a wide cavity lined with ten epithelial cells.

4. A tracheid adjoining a vessel (*v*) and similar tracheids (*tr*), showing the characteristic pits (*p*) leading from a tracheid to a vessel. Camera lucida drawing; × 2,260.

PLATE 6

Parashorea malaanonan, radial section of wood, *22677 B. F.*; × 50. Note the heterogeneous cells composing the wood or pith rays.

PLATE 7

Parashorea malaanonan, radial section of wood, *22677* B. F.; × 200. Showing idioblasts with calcium oxalate crystals in them.

PLATE 8

Parashorea malaanonan, tangential section, *22677 B. F.*; × 50.

PLATE 9

FIG. 1. Longitudinal view of a bordered pit leading from one vessel to another vessel.

2. Longitudinal view of a bordered pit leading from a vessel to a tracheid.
3. Lateral view of a bordered pit leading from vessel to vessel.
4. Longitudinal view of a semibordered pit leading from a vessel to a wood or vertical parenchyma.
5. Longitudinal view of a semibordered pit leading from tracheid to parenchyma.
6. Longitudinal view of a bordered pit leading from a tracheid to another tracheid.
7. Longitudinal view of a bordered pit leading from a vessel to a libriform fiber. Note the reduced size of the pit in the vessel wall.
8. Longitudinal view of a semibordered pit leading from a libriform fiber to a wood parenchyma.
9. Longitudinal view of a bordered pit leading from a libriform fiber to another libriform fiber.
10. Vertical view of a bordered pit.
11. Vertical view of simple pits.
12. Longitudinal view of simple pits leading from wood parenchyma to parenchyma cells.

PLATE 10

Vatica mangachapoi Blanco, cross section of wood, *9043 B. F.*; × 50.

PLATE 11

Dipterocarpus grandiflorus Blanco, cross section of wood, *17581 B. F.*; × 50.

PLATE 12

Dipterocarpus vernicifluus Blanco, cross section of wood, *2131 B. F.*; × 50.

PLATE 13

Dipterocarpus lasiopodus Perkins, cross section of wood, *2031 Merrill*; × 50.

PLATE 14

Anisoptera thurifera (Blanco) Blume, cross section of wood, *17585 B. F.;* × 50.

PLATE 15

Anisoptera curtisii Dyer, cross section of wood, *8985 B. F.;* × 50.

PLATE 16

Shorea palosapis (Blanco) Merrill, cross section of wood, *20708 B. F.;* × 50.

PLATE 17

Shorea teysmanniana Dyer, cross section of wood, *27041 B. F.;* × 50.

PLATE 18

Shorea negrosensis Foxworthy, cross section of wood, *17490 B. F.;* × 50.

PLATE 19

Shorea polysperma (Blanco) Merrill, cross section of wood, *17468 B. F.* from Negros; × 50. Vessels here are more numerous and the libriform fibers are thinner walled than in specimens from Bataan.

PLATE 20

Shorea polysperma (Blanco) Merrill, cross section of wood, *6324 B. F.* from Bataan; × 50. Note the thick-walled libriform fibers and the fewer vessels as compared with Plate 19 of Negros wood.

PLATE 21

Shorea mindanensis Foxworthy, cross section of wood, *9372 B. F.;* × 50.

PLATE 22

Parashorea malaanonan (Blanco) Merrill, cross section of wood, *22677 B. F.*, showing the distribution of pores, vertical or wood parenchyma, and resin canals; × 50.

PLATE 23

Shorea eximia Scheffler, cross section of wood, *17490 B. F.;* × 50.

PLATE 24

Pentacme mindanensis Foxworthy, cross section of wood, *25193 B. F.;* × 50.

PLATE 25

Pentacme contorta (Vidal) Merrill and Rolfe, cross section of wood, *5961 B. F.;* × 50.

PLATE 26

Isoptera borneensis Scheffler, cross section of wood, *9374 B. F.;* × 50.

PLATE 27

Shorea balangeran (Korthals) Dyer, cross section of wood, *15002 B. F.;* × 50. The prominent dark spots are calcium oxalate crystals.

PLATE 28

Shorea guiso (Blanco) Blume, cross section of wood, *5387 B. F.*; × 50.

PLATE 29

FIG. 1. *Balanocarpus cagayanensis* Foxworthy, cross section of wood, *26624 B. F.*; × 50.

2. *Hopea mindanensis* Foxworthy, cross section of wood, *9376 B. F.*; × 50.

PLATE 30

FIG. 1. *Hopea acuminata* Merrill, cross section of wood, *17595 B. F.*; × 50.

2. *Hopea philippinensis* Dyer, cross section of wood, *9376 B. F.*; × 50.

PLATE 31

FIG. 1. *Hopea pierrei* Hance, cross section of wood, *17771 B. F.*; × 50. Note the peculiar disposition of parenchyma cells which tend to bunch themselves on one side of the vessel.

2. *Hopea plagata* Vidal, cross section of wood, *22167 B. F.*; × 50.

PLATE 1. LARGE DIPTEROCARPS IN NORTHERN NEGROS.

Oversized Foldout

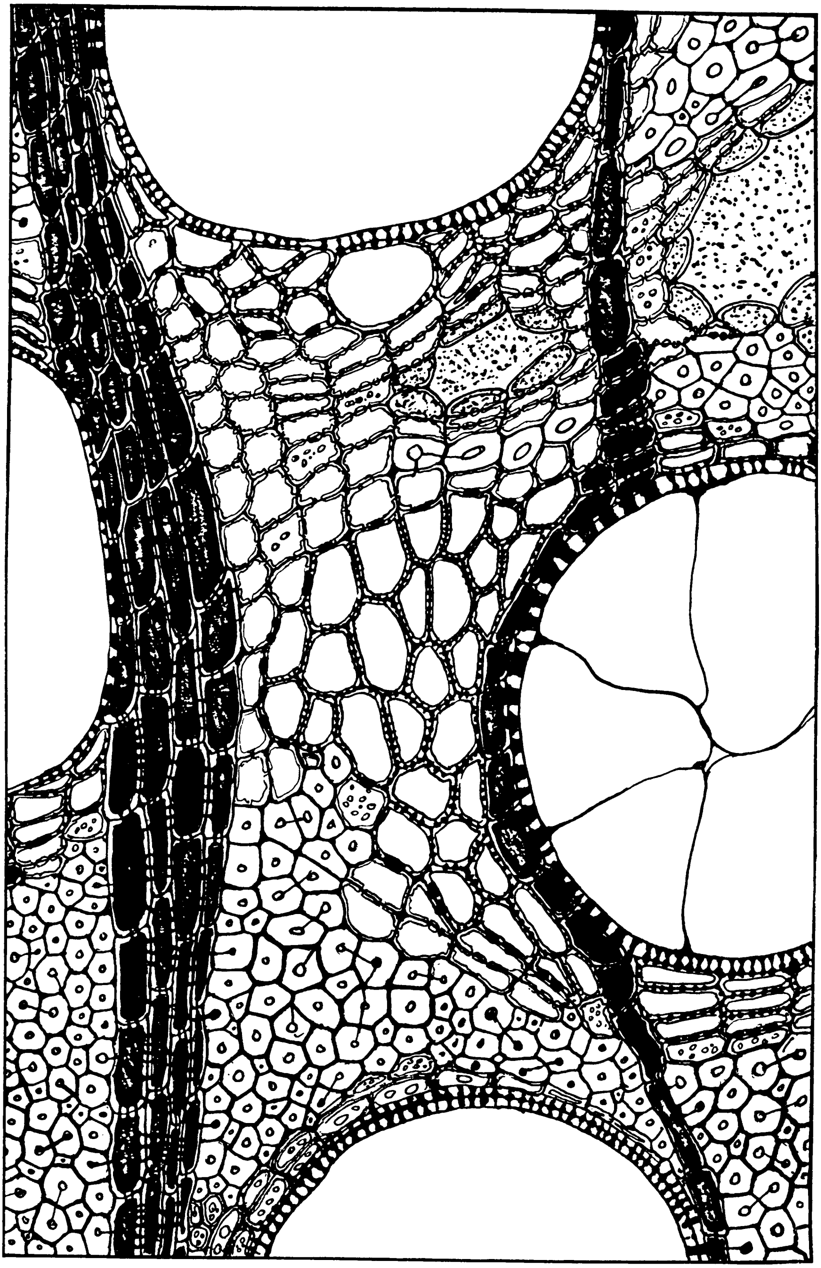

PLATE 3. A CROSS SECTION OF PARASHOREA WOOD.

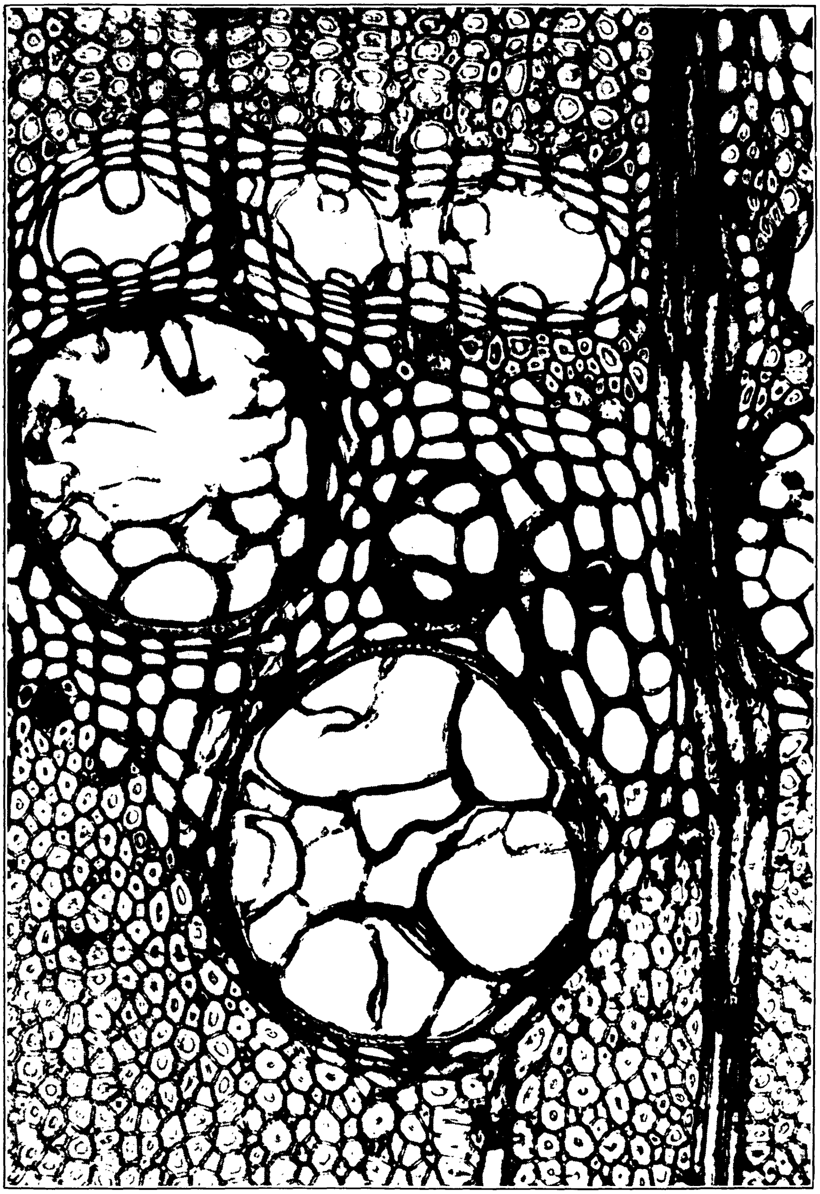

PLATE 4. A CROSS SECTION OF PARASHOREA WOOD.

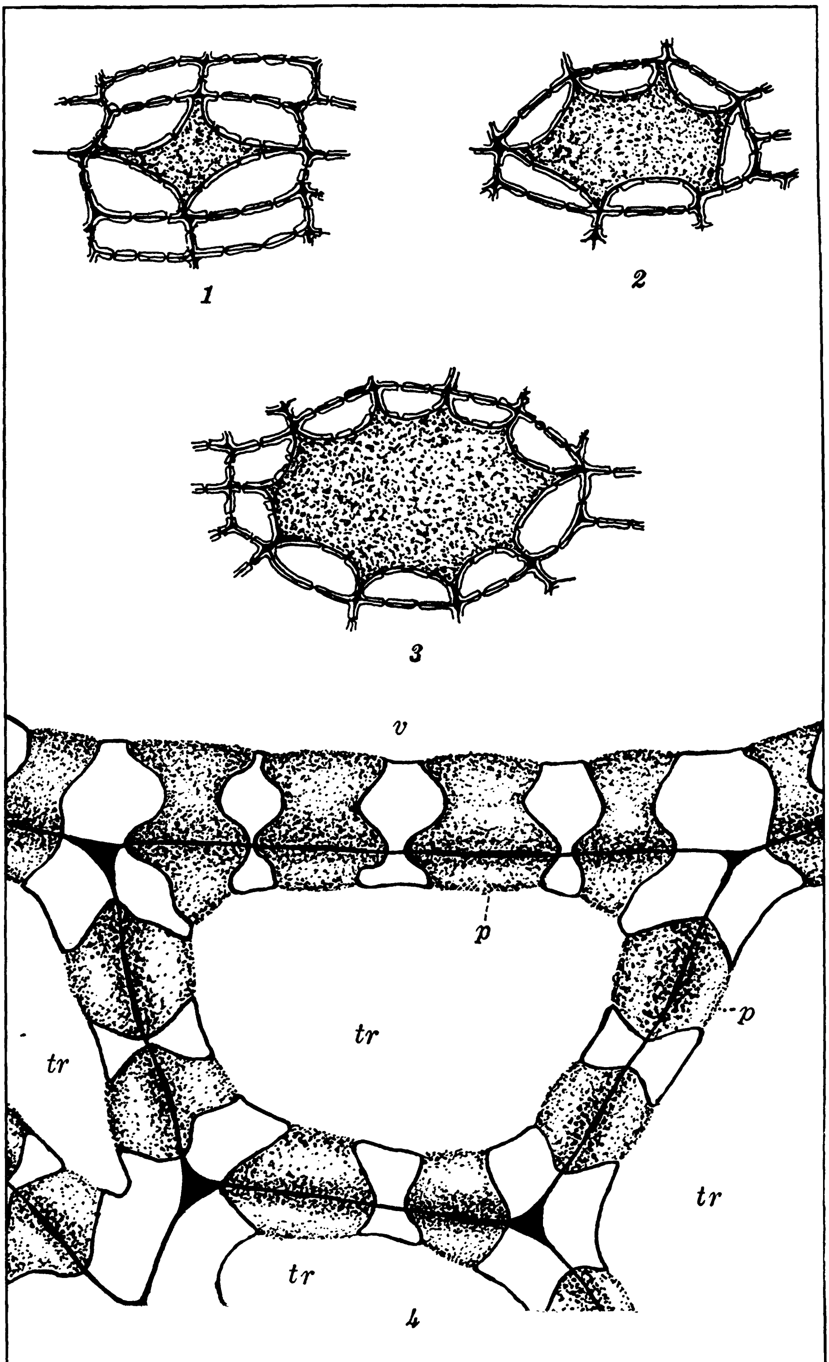

PLATE 5. DIAGRAMMATIC PRESENTATION OF FORMATION OF RESIN CANALS, × 270.

PLATE 6. RADIAL SECTION OF WOOD OF PARASHOREA MALAANONAN, × 50.

PLATE 7. RADIAL SECTION OF WOOD OF PARASHOREA MALAANONAN, × 200.

PLATE 8. TANGENTIAL SECTION OF WOOD OF PARASHOREA MALAANONAN, × 50.

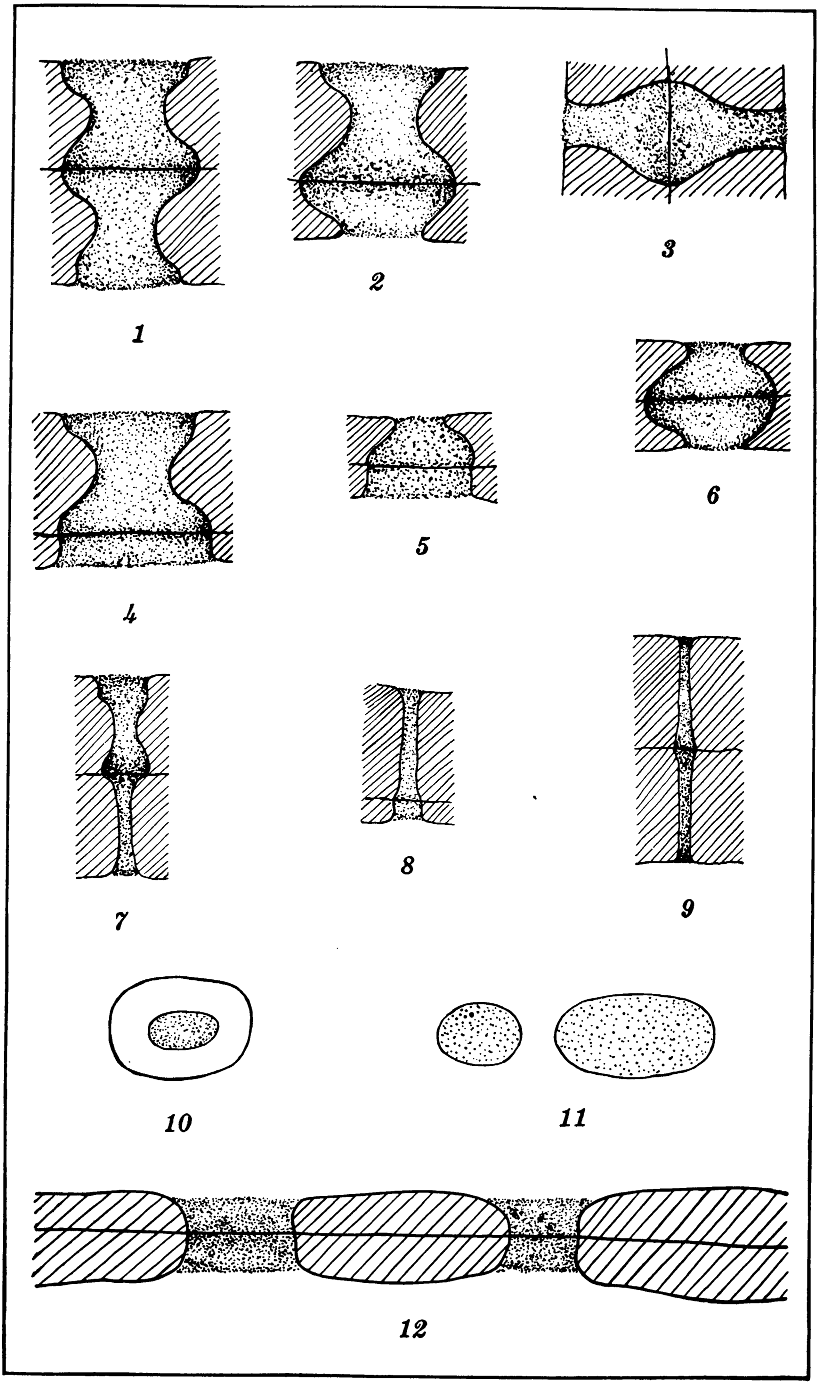

PLATE 9. BORDERED, SEMIBORDERED, AND SIMPLE PITS.

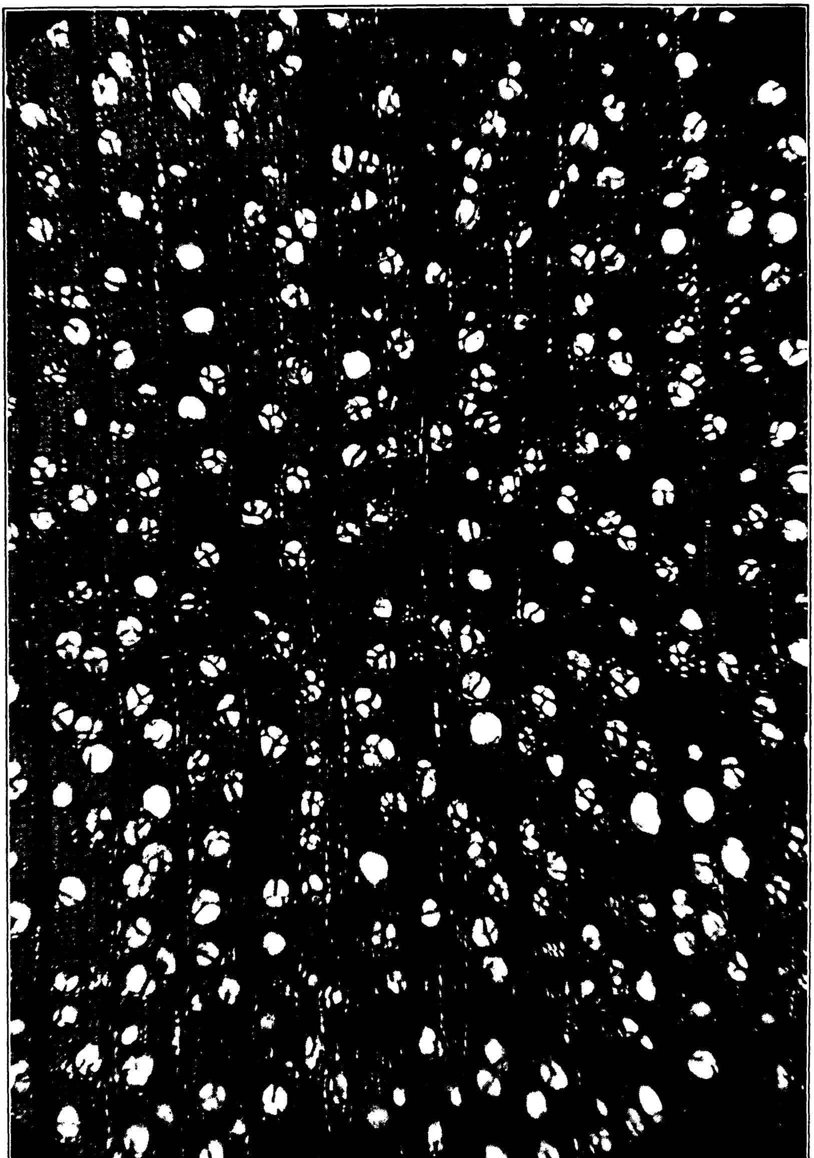

PLATE 10. CROSS SECTION OF WOOD OF VATICA MANGACHAPOI, × 50.

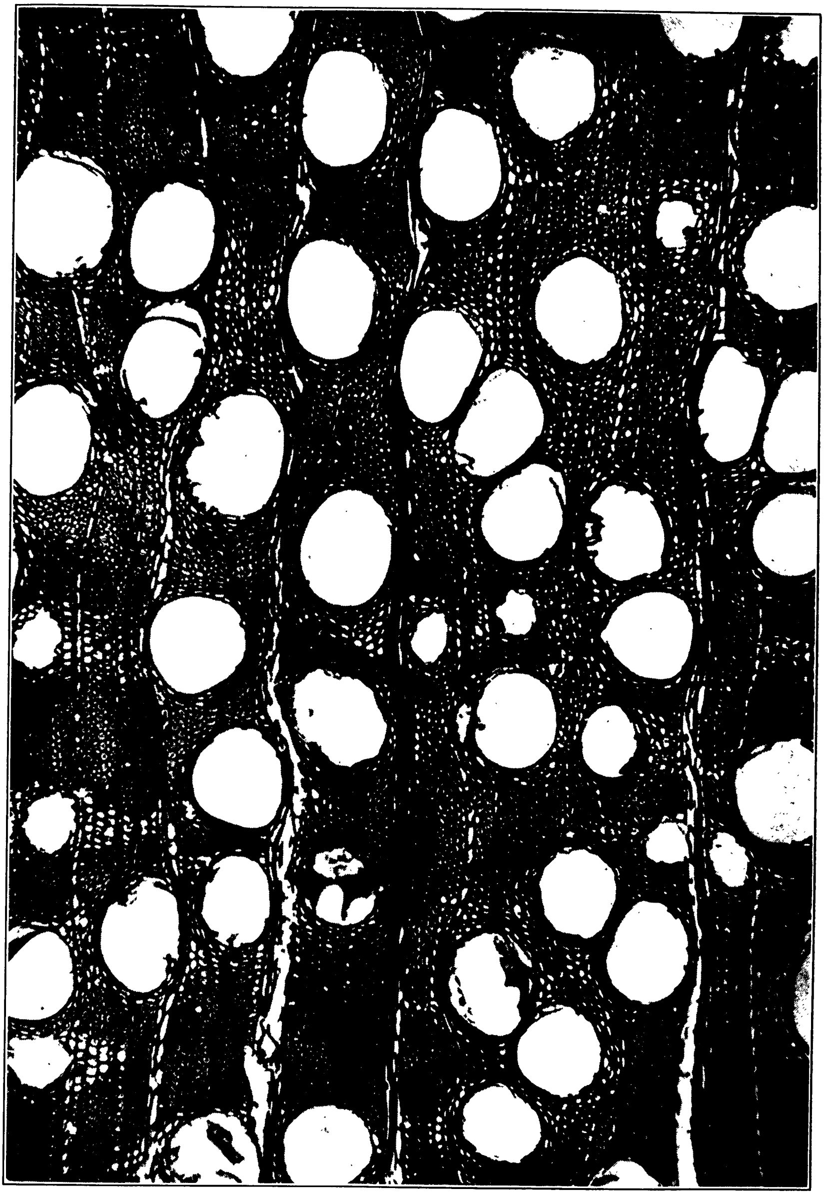

PLATE 11. CROSS SECTION OF WOOD OF DIPTEROCARPUS GRANDIFLORUS, × 50.

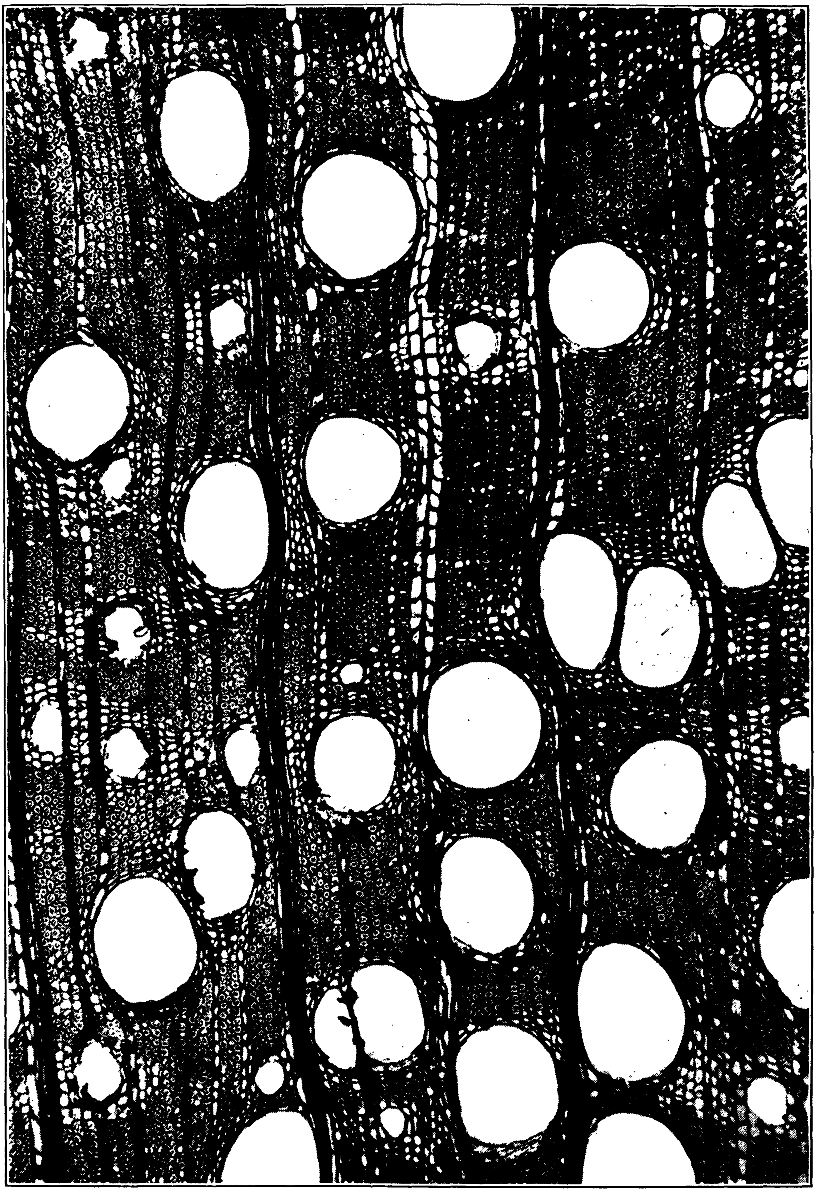

PLATE 12. CROSS SECTION OF WOOD OF DIPTEROCARPUS VERNICIFLUUS, × 50.

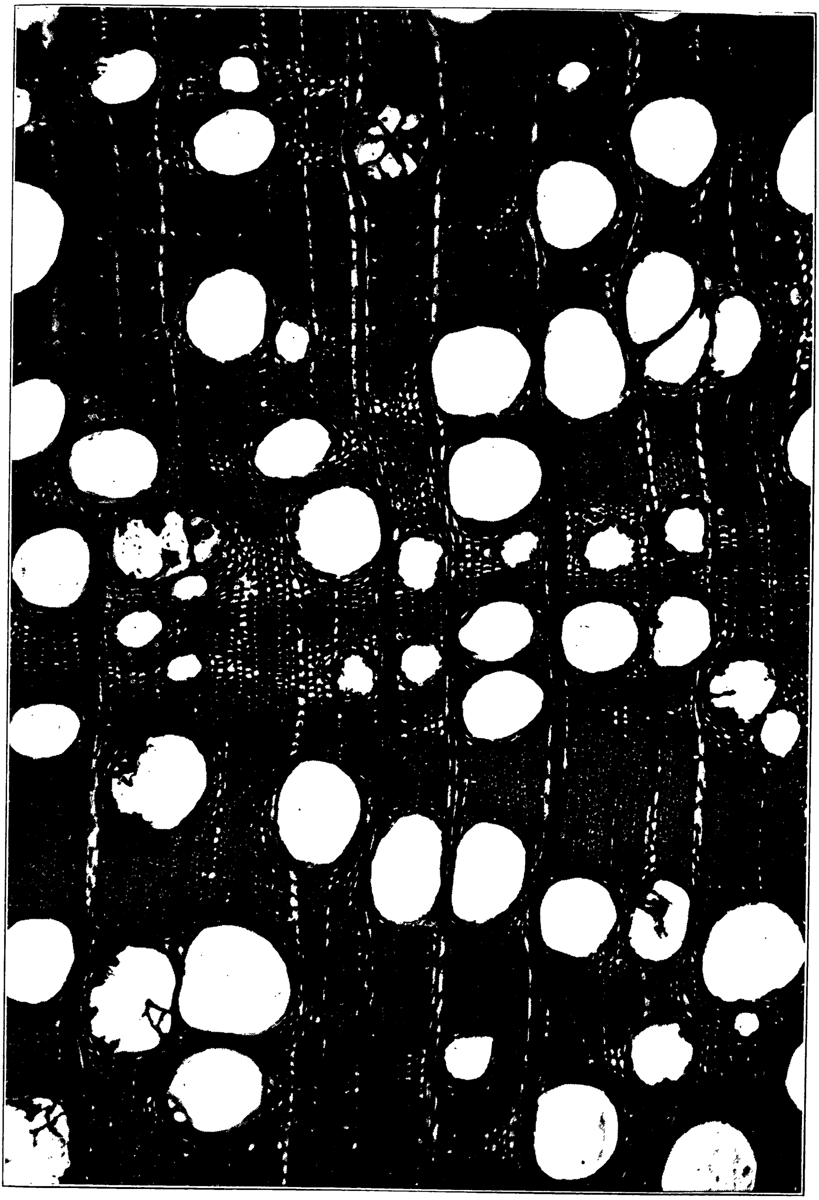

PLATE 13. CROSS SECTION OF WOOD OF DIPTEROCARPUS LASIOPODUS, × 50.

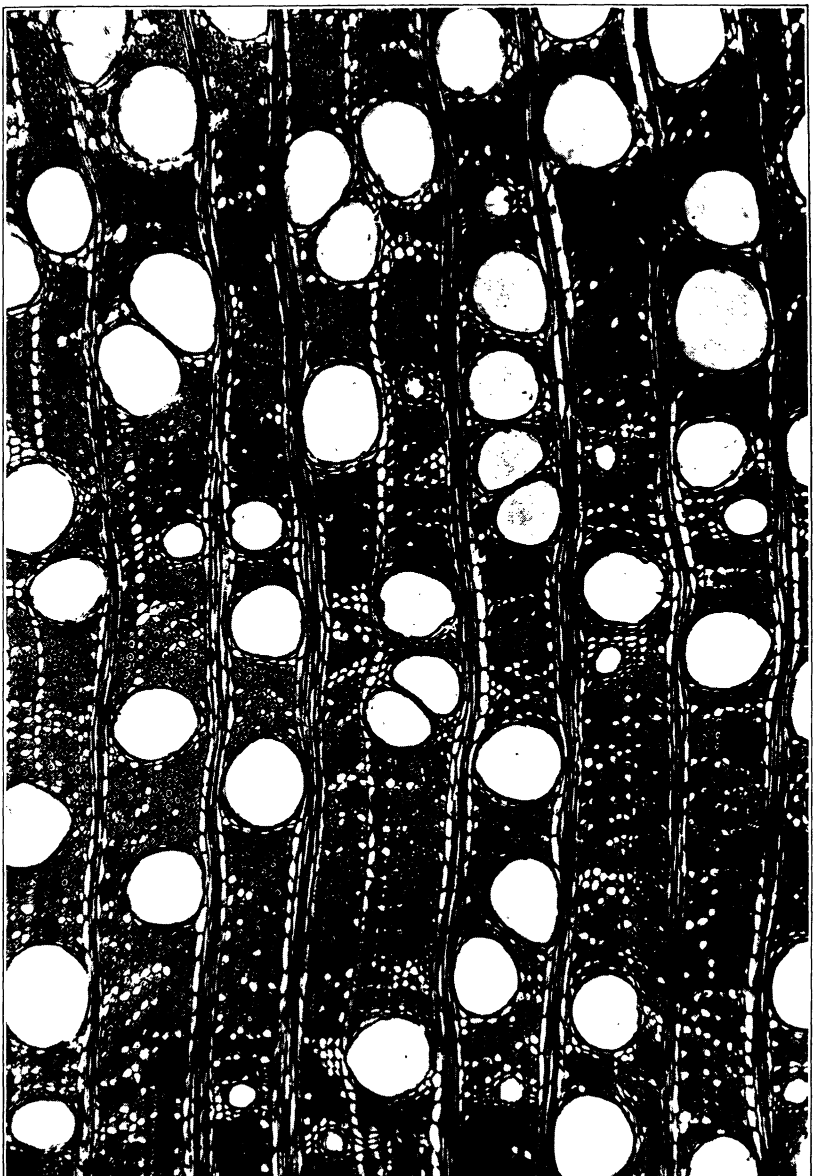

PLATE 14. CROSS SECTION OF WOOD OF ANISOPTERA THURIFERA, × 50.

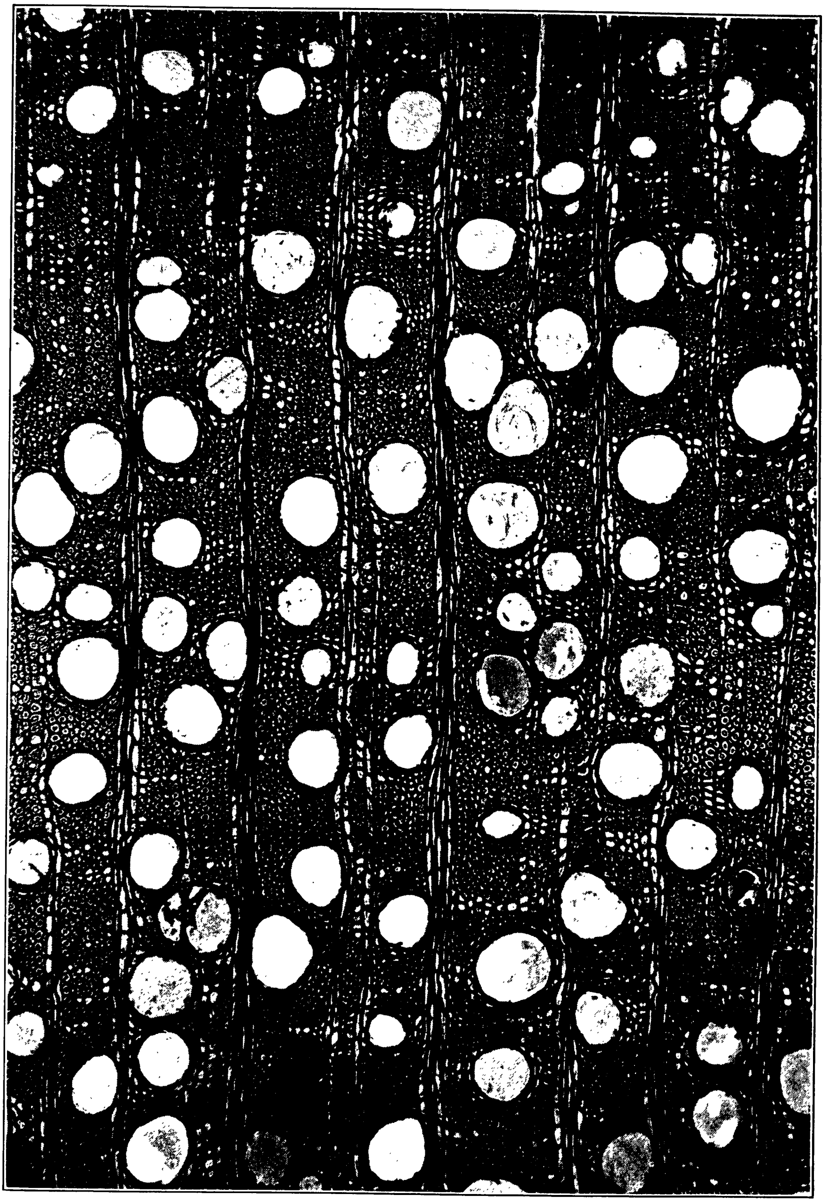

PLATE 15. CROSS SECTION OF WOOD OF ANISOPTERA CURTISII, × 50.

PLATE 16. CROSS SECTION OF WOOD OF SHOREA PALOSAPIS, × 50.

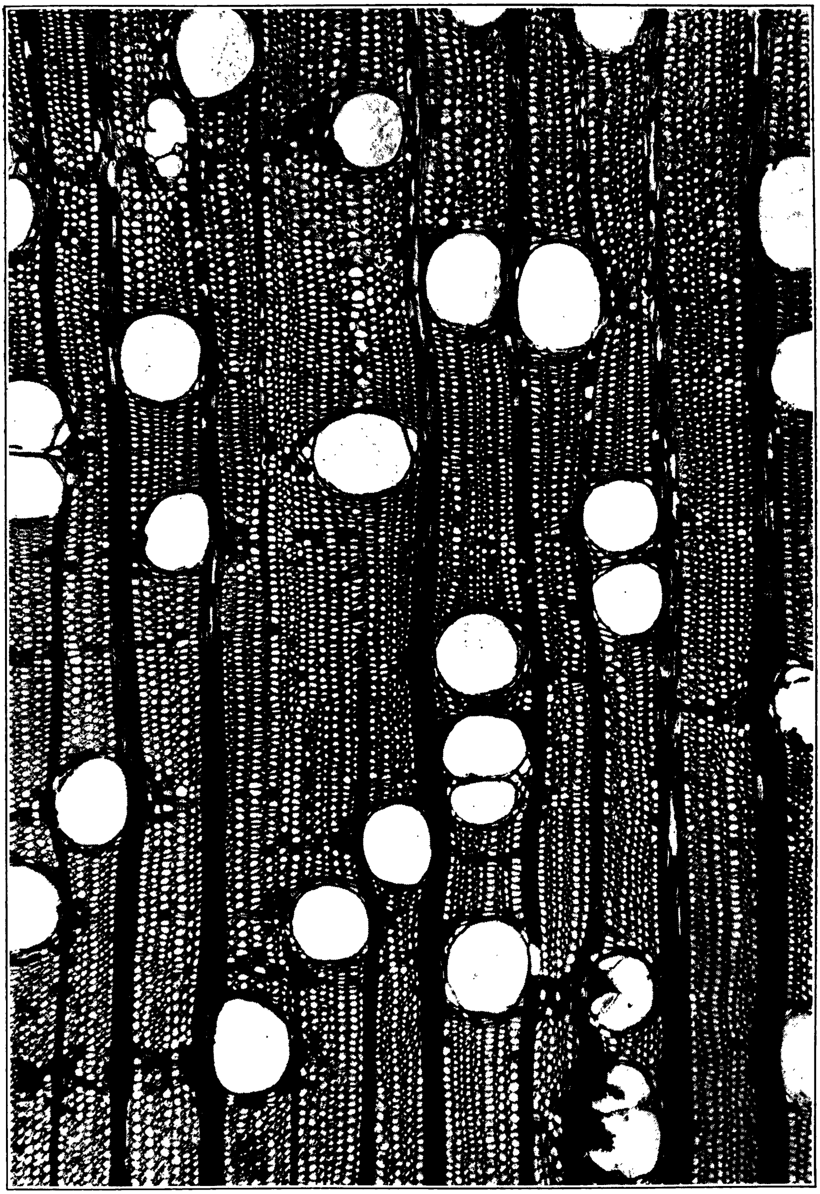

PLATE 17. CROSS SECTION OF WOOD OF SHOREA TEYSMANNIANA, × 50.

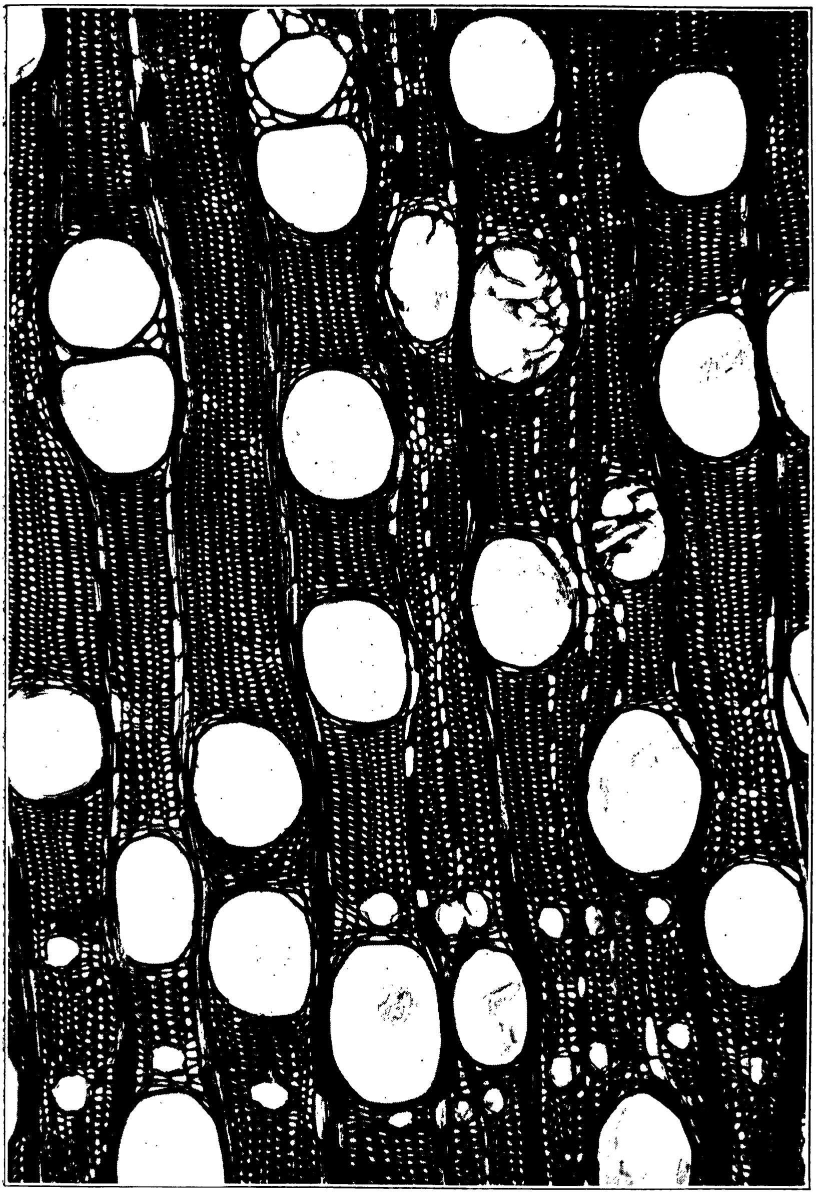

PLATE 18. CROSS SECTION OF WOOD OF SHOREA NEGROSENSIS, × 50.

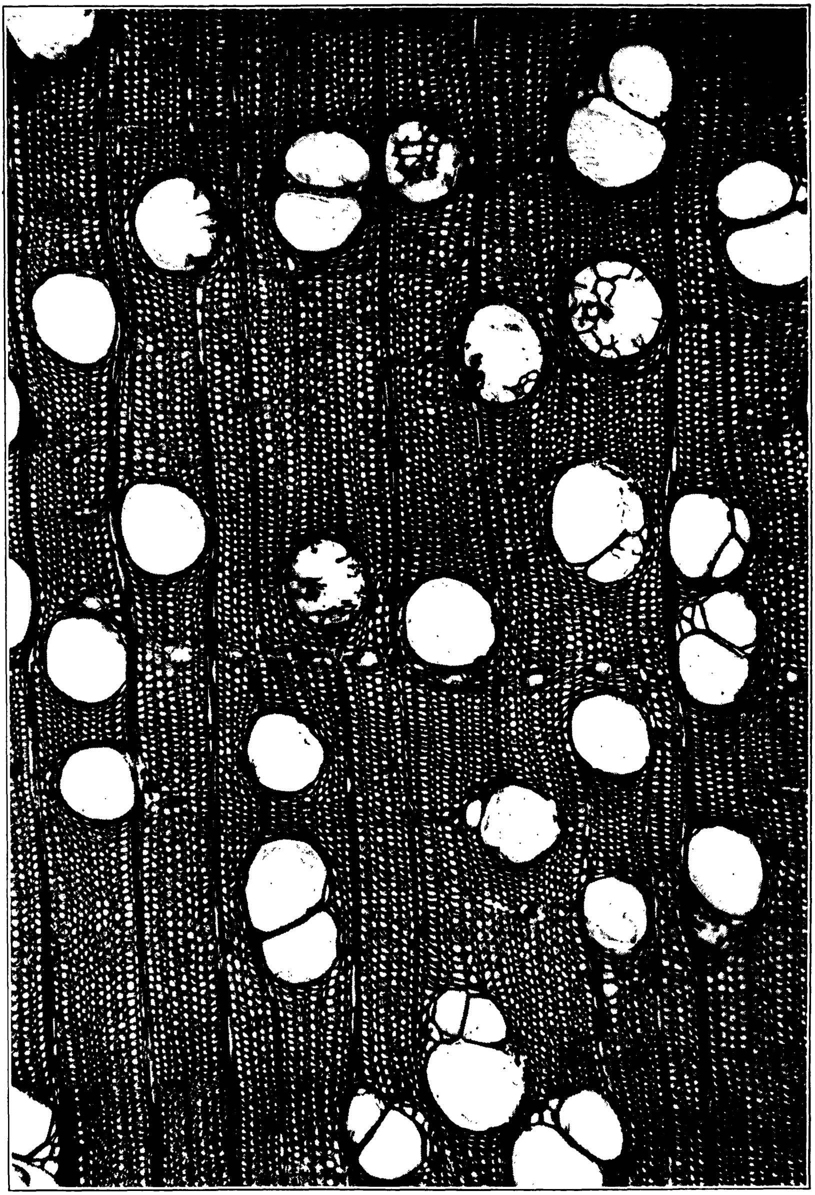

PLATE 19. CROSS SECTION OF WOOD OF SHOREA POLYSPERMA, FROM NEGROS, × 50.

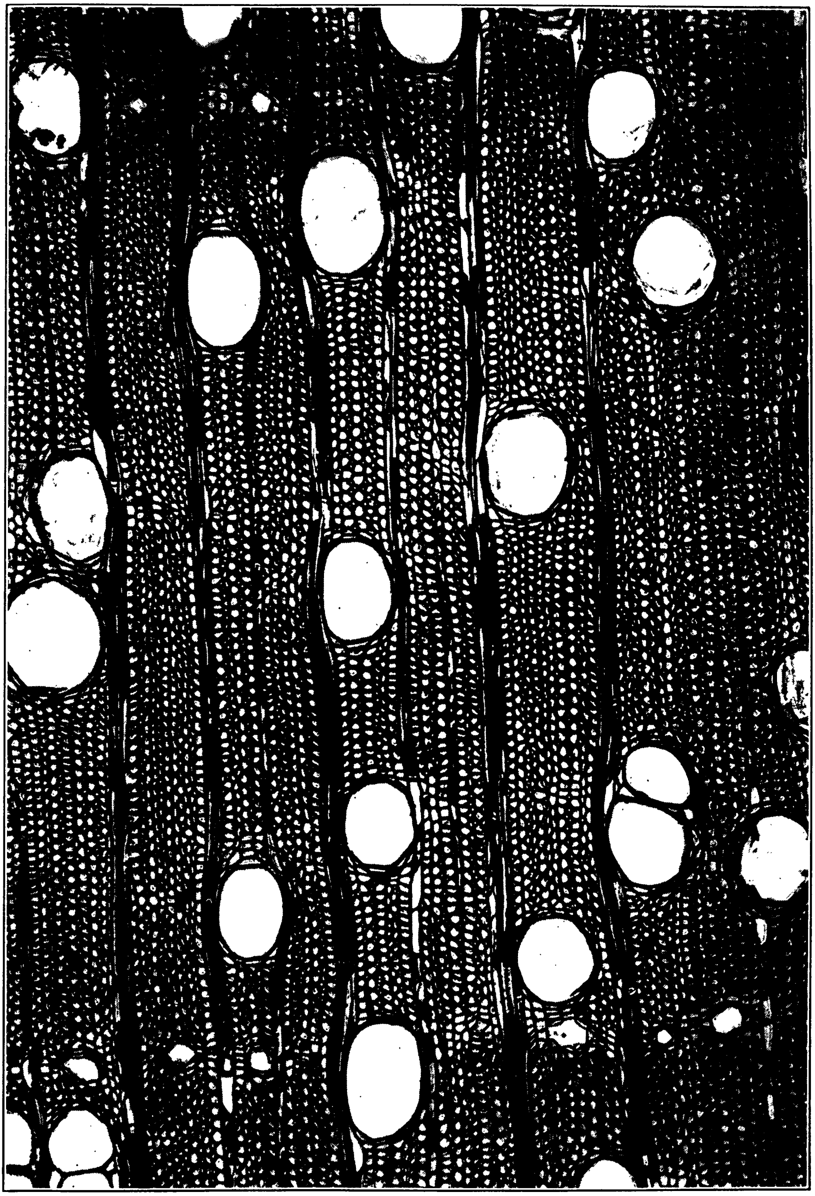

PLATE 20. CROSS SECTION OF WOOD OF SHOREA POLYSPERMA, FROM BATAAN, × 50.

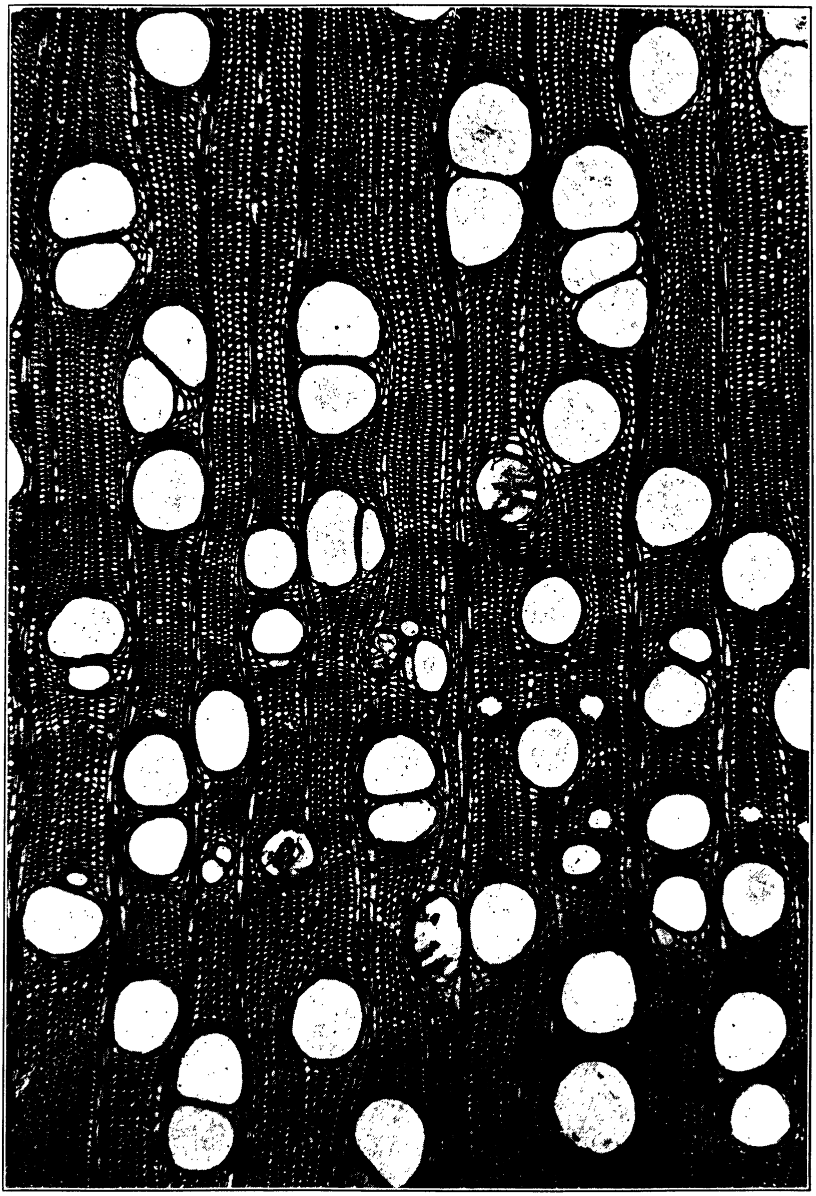

PLATE 21. CROSS SECTION OF WOOD OF SHOREA MINDANENSIS, × 50.

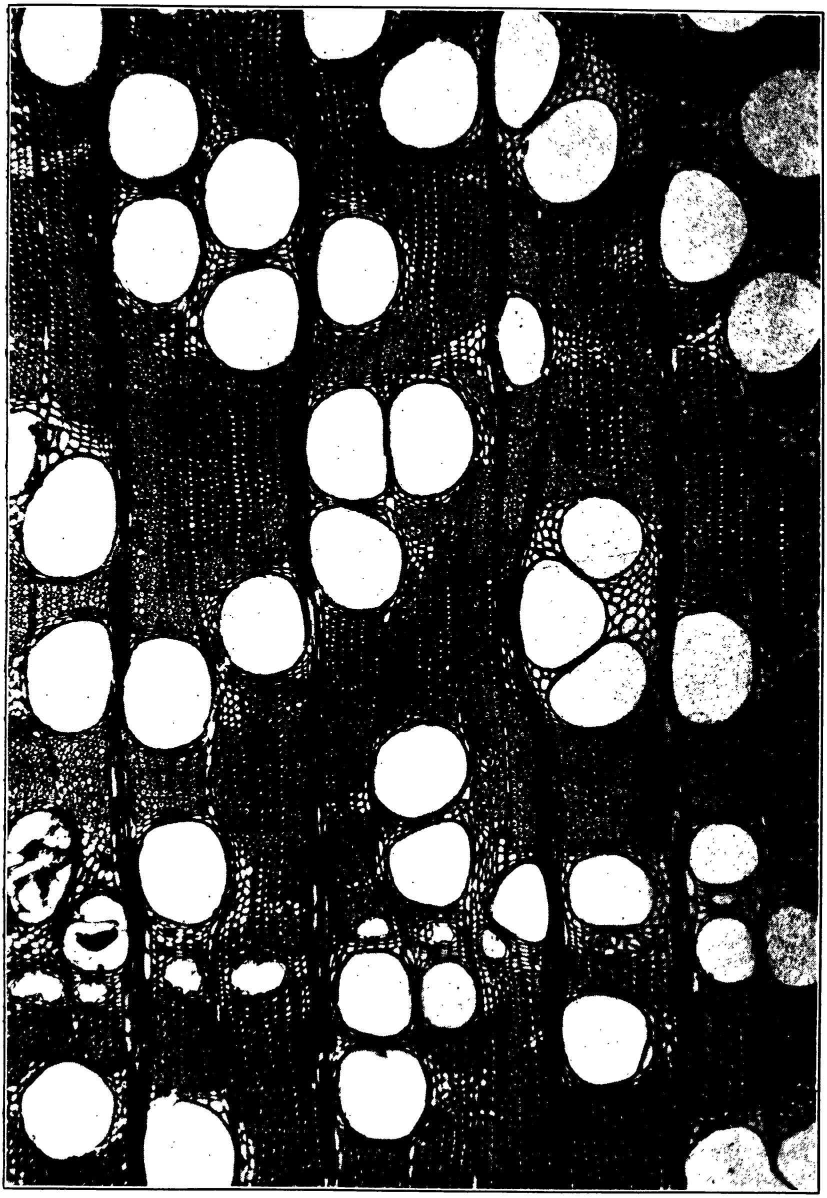

PLATE 22. CROSS SECTION OF WOOD OF PARASHOREA MALAANONAN, × 50.

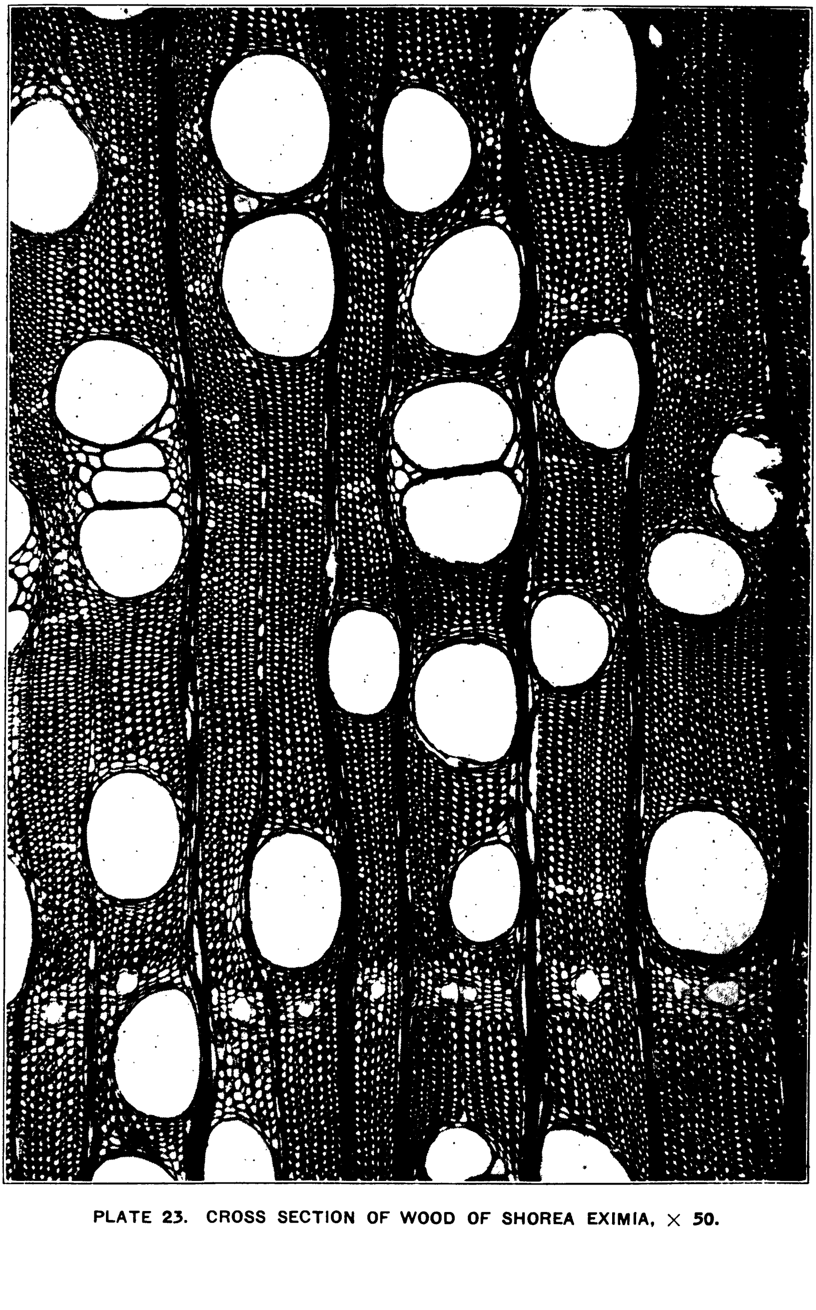

PLATE 23. CROSS SECTION OF WOOD OF SHOREA EXIMIA, × 50.

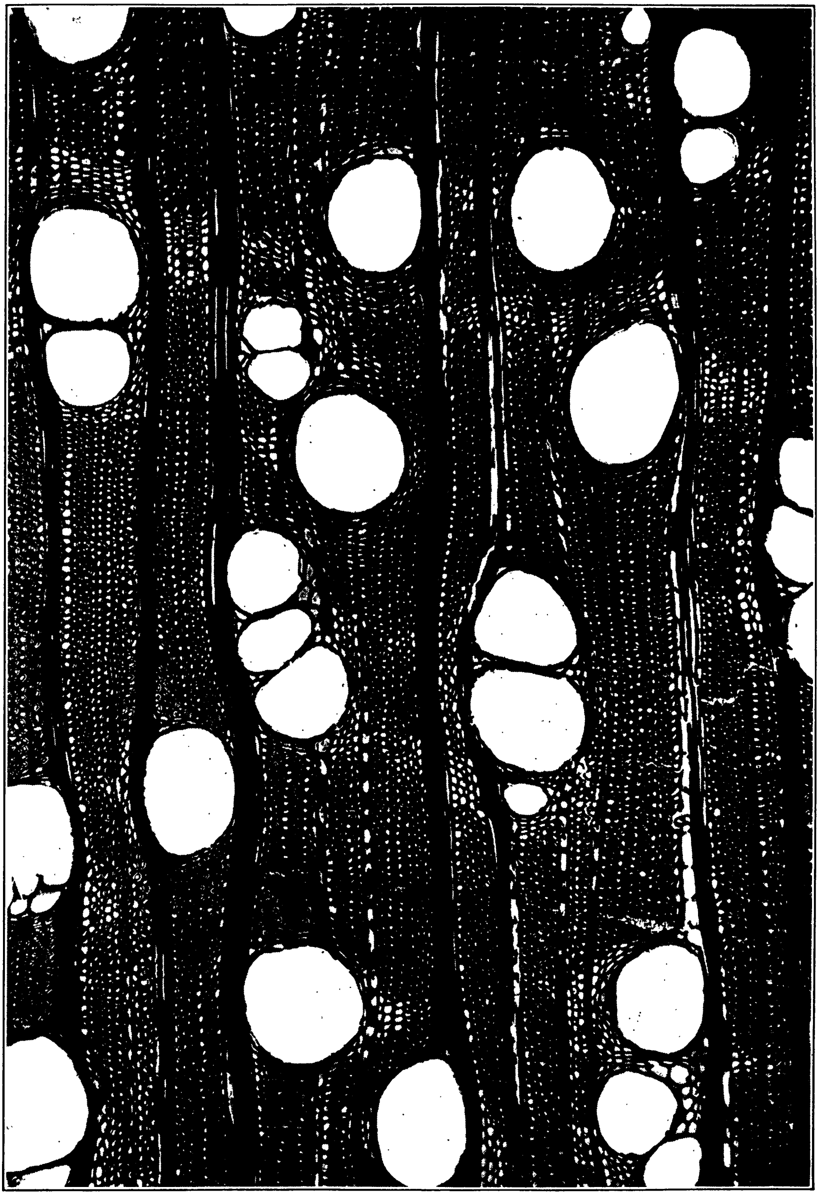

PLATE 24. CROSS SECTION OF WOOD OF PENTACME MINDANENSIS, × 50.

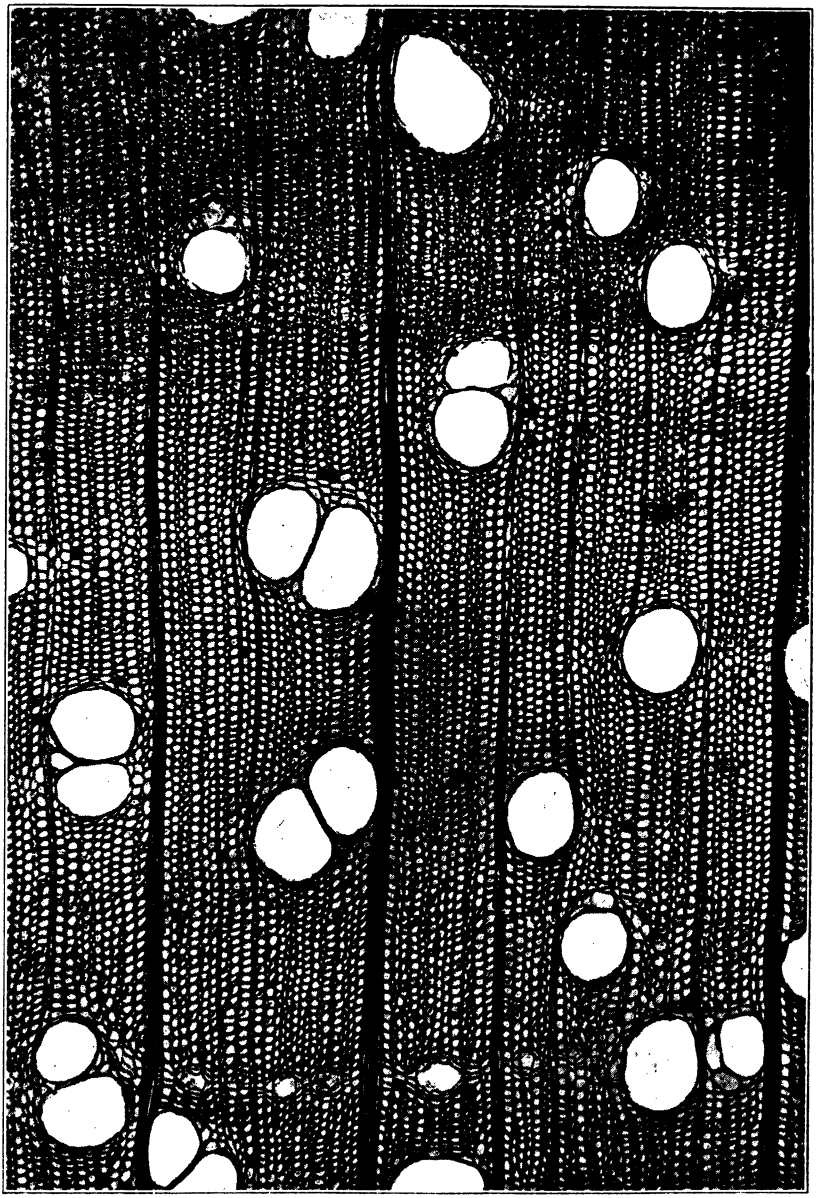

PLATE 25. CROSS SECTION OF WOOD OF PENTACME CONTORTA, × 50.

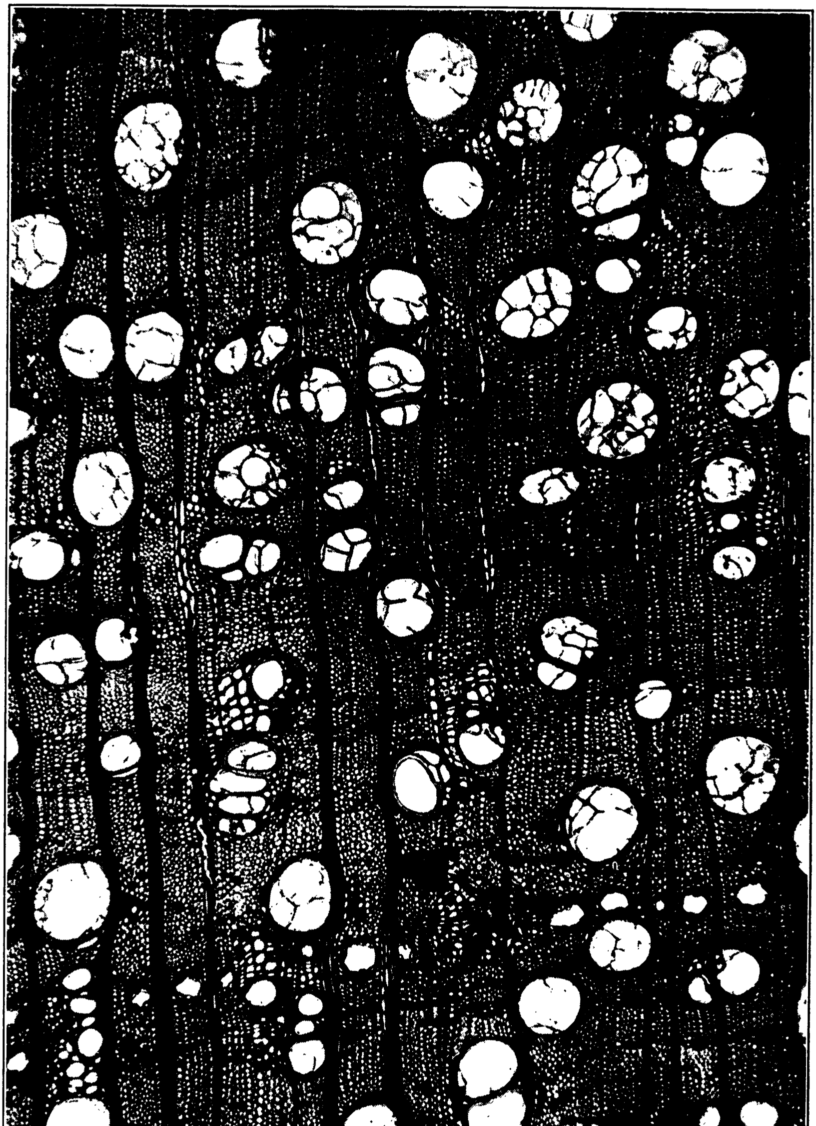

PLATE 26. CROSS SECTION OF WOOD OF ISOPTERA BORNEENSIS, × 50.

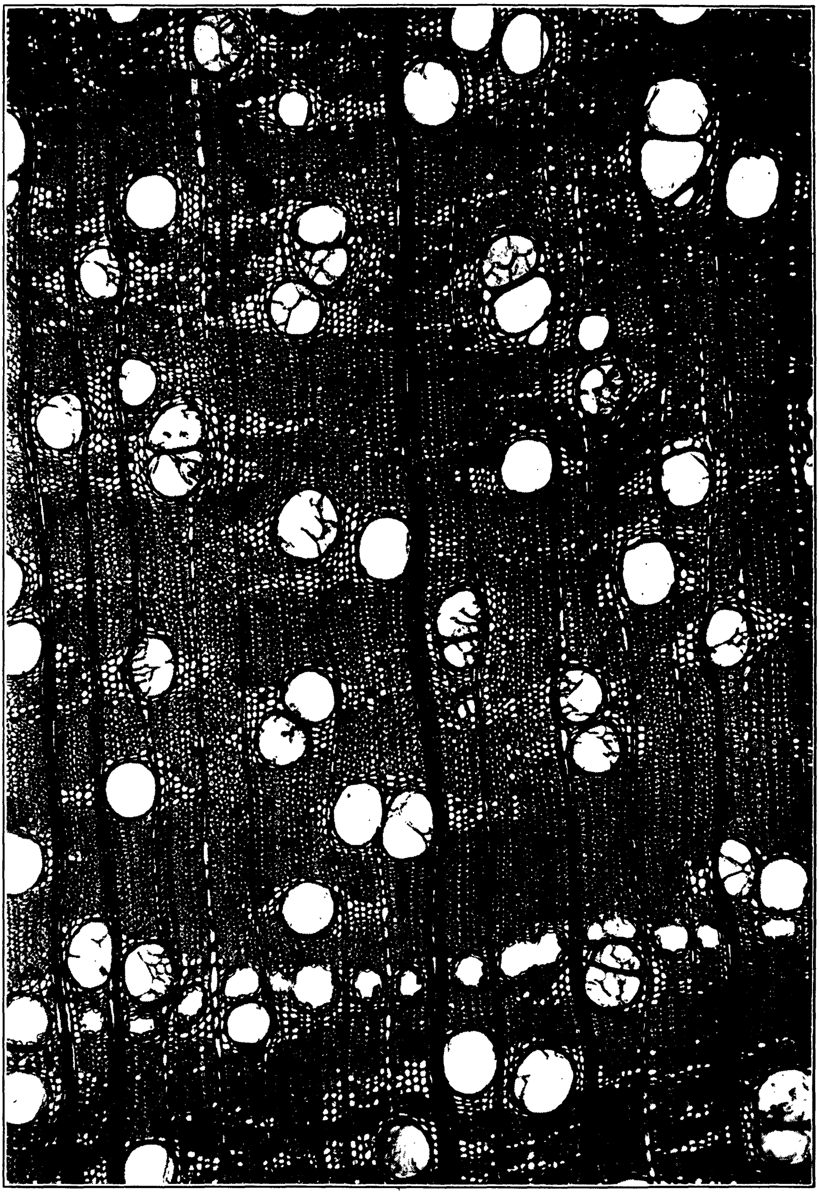

PLATE 27. CROSS SECTION OF WOOD OF SHOREA BALANGERAN, × 50.

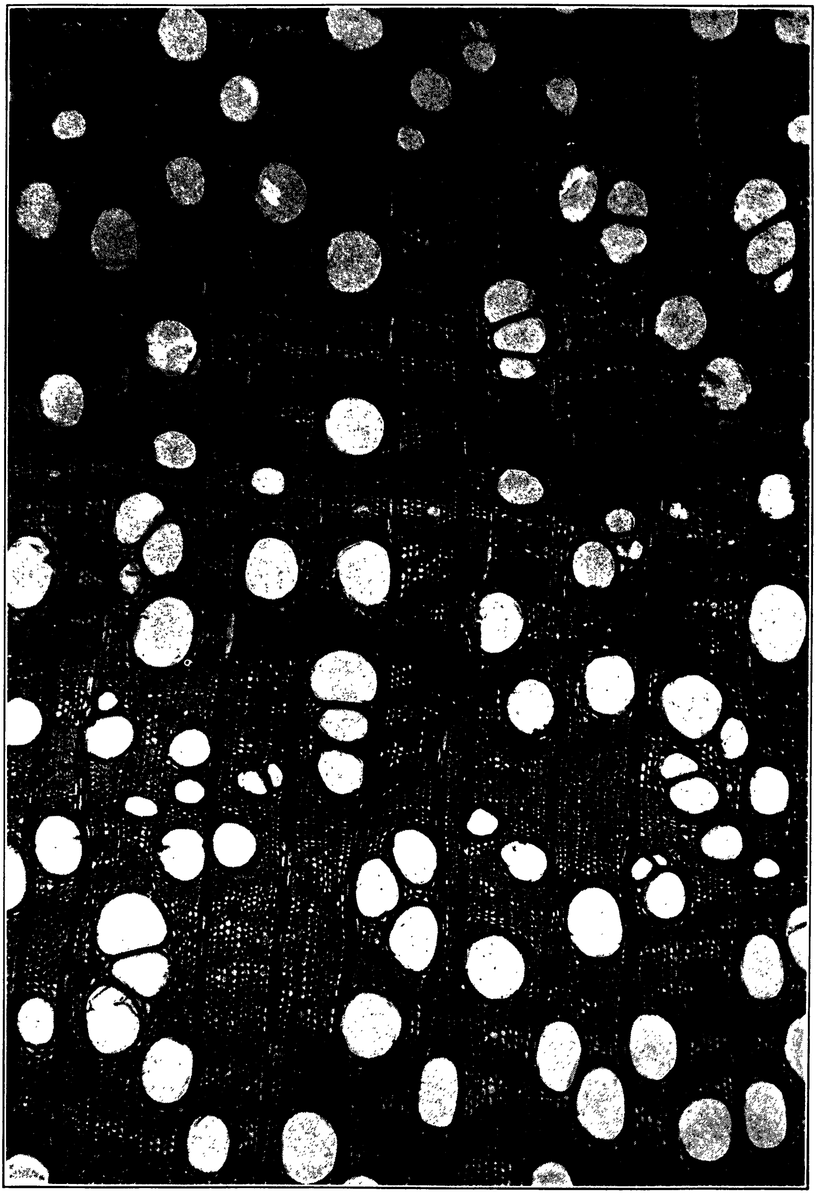

PLATE 28. CROSS SECTION OF WOOD OF SHOREA GUISO, × 50.

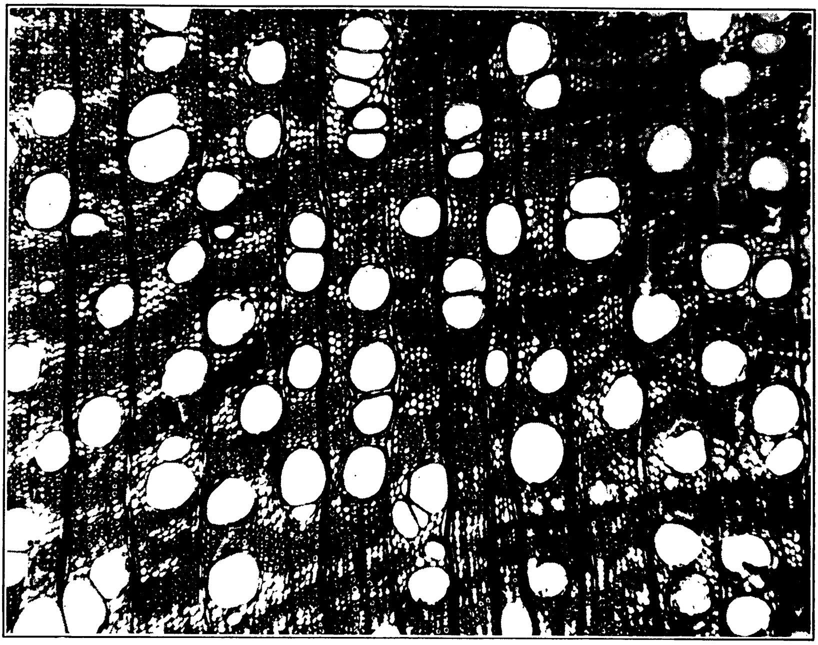

Fig. 1. Cross section of wood of Balanocarpus cagayanensis, × 50.

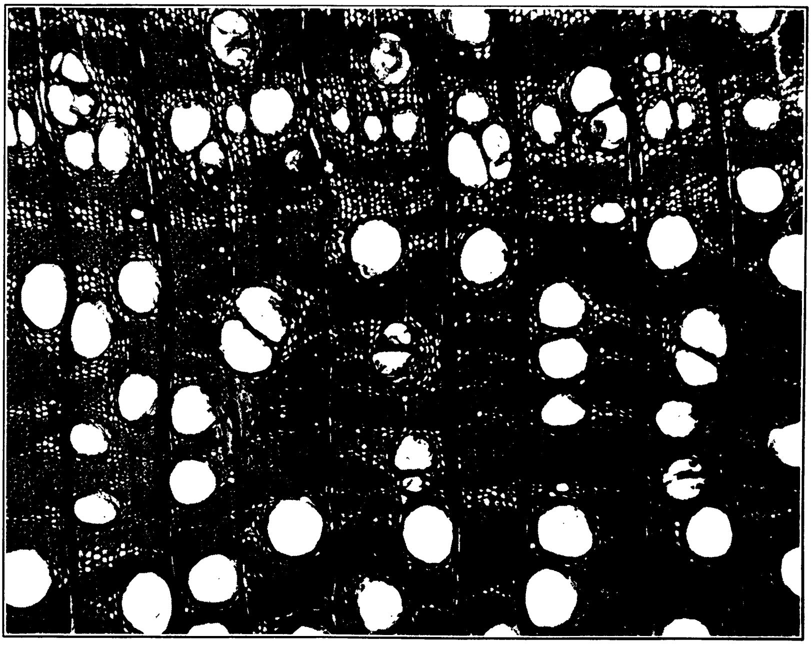

Fig. 2. Cross section of wood of Hopea mindanensis, × 50.

PLATE 29.

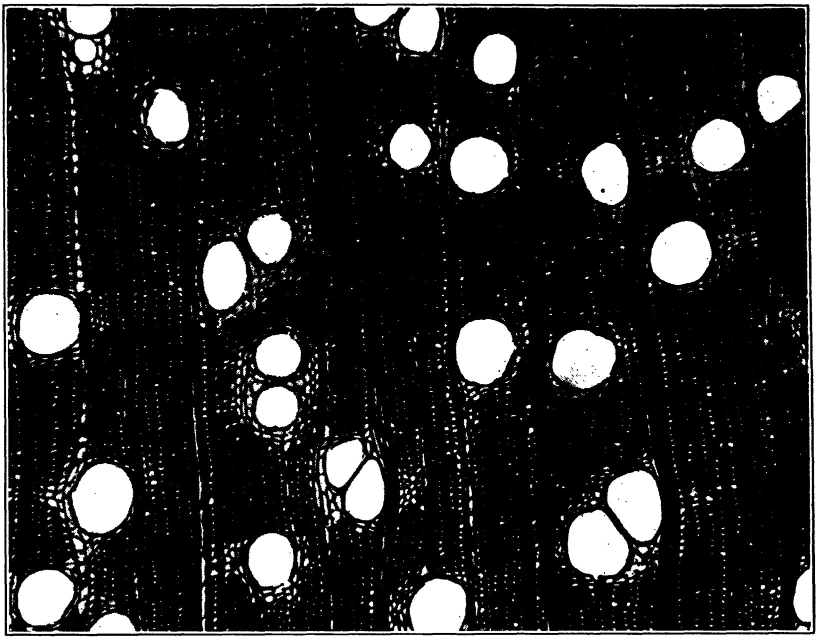

Fig 1. Cross section of wood of Hopea acuminata, × 50.

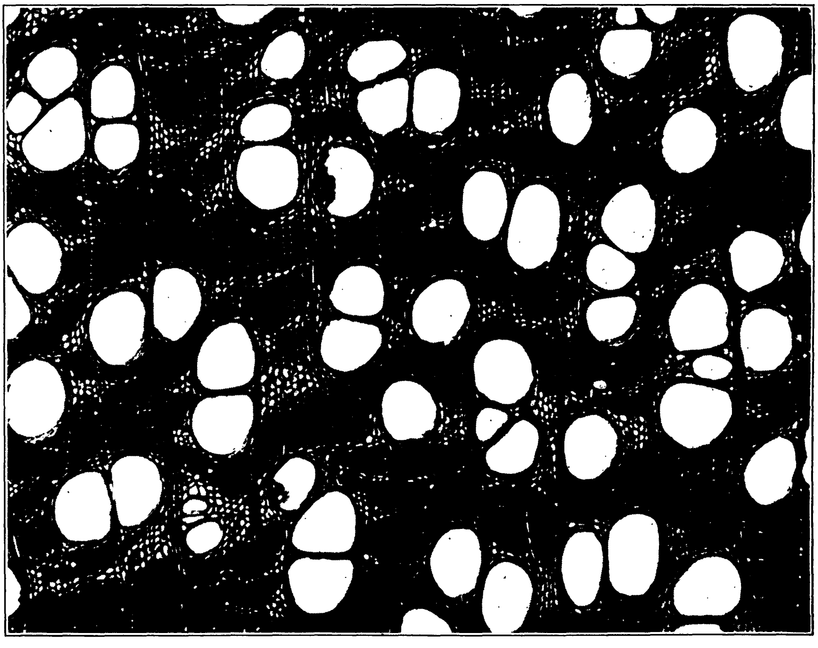

Fig. 2. Cross section of wood of Hopea philippinensis, × 50.

PLATE 30.

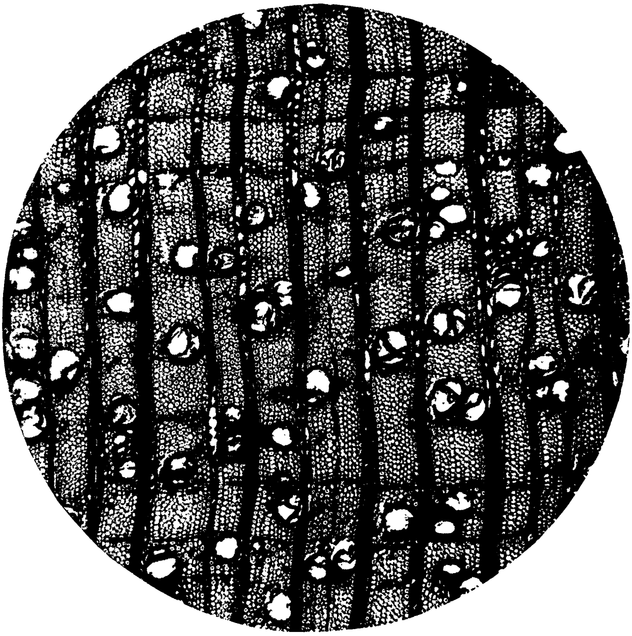

Fig. 1. Cross section of wood of Hopea pierrei, × 50.

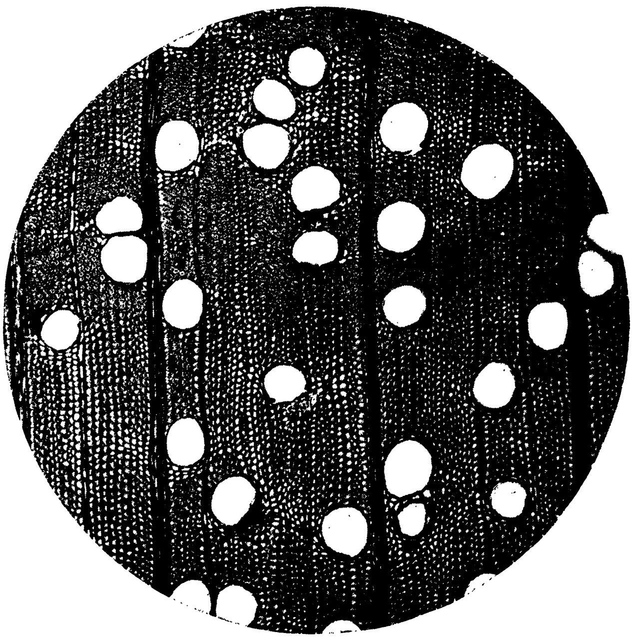

Fig 2. Cross section of wood of Hopea plagata, × 50.

PLATE 31.

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THE PHILIPPINE
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VOL. 22 APRIL, 1923 No. 4

NEW HYMENOPTERA FROM THE MALAYAN REGION

By S. A. ROHWER

Honorary Custodian of Hymenoptera, United States National Museum

ONE TEXT FIGURE

In identifying some Philippine Hymenoptera submitted by Prof. C. S. Banks, of the Philippine Bureau of Science, certain new species were found. Descriptions of these are included in the following pages. In reporting on this material it seemed advisable to add descriptions of certain related species, and the descriptions of new species from Singapore are also included. The types of all the forms here described are in the United States National Museum.

CHALICIDIDÆ

Genus **DIRHINUS** Dalman

The genus *Dirhinus* Dalman in current classifications is separated from *Eniaca* Kirby by the number of antennal joints; *Dirhinus* is said to have 12-jointed antennæ, while the antennæ of *Eniaca* are described as 13-jointed. A careful examination of the genotypes shows that these characters have been inaccurately described and that, although there is a difference in the antennæ, this difference does not consist in the number of joints but rather in the relative length of the third joint. In *Dirhinus* the third joint is very short and easily overlooked, while in *Eniaca* the third joint is long and plainly visible. The differences in the antennæ of the two genera are illustrated in the accompanying figure (fig. 1). From an examination of the

specimens in the United States National Museum I was unable to find any other characters which might be considered of generic value and, although I doubt the advisability of considering such

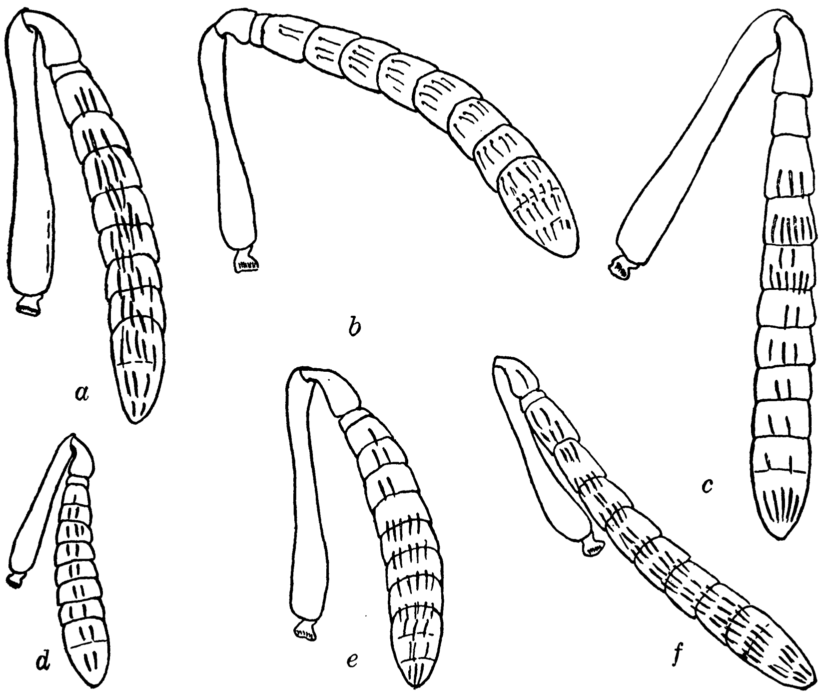

FIG. 1. Antennæ of *Dirhinus* and *Eniaca*. *a*, *Dirhinus luciliae* sp. nov. (type); *b*, *D. excavatus* Dalman; *c*, *Eniaca hesperidumi* Rossi; *d*, *D. banksi* sp. nov. (type); *e*, *D. luzonensis* sp. nov. (type); *f*, *D. auratus* Ashmead, male.

differences in the antennæ as generic, it seems undesirable at the present to suppress the name *Eniaca*. Until more material of this group can be studied I suggest that *Eniaca* be treated as a genus and distinguished from its ally *Dirhinus* as follows:

Third antennal joint at least twice as wide as long, not sharply separated from fourth........ **Dirhinus Dalman.**
Third antennal joint longer than wide, easily seen, and separated from fourth........ **Eniaca Kirby.**

Key to Philippine species of Dirhinus in collection of the United States National Museum

1. Scutellum with uniform umbilicate punctures; antennæ and four anterior legs red........ **D. auratus Ashmead.**
   Central portion of scutellum smooth and shining........ 2.
2. Pronotum uniformly closely punctured; seen from above the horns of head have a small tooth apically; four anterior legs piceous.
   D. banksi sp. nov.

Pronotum shining, with large well-separated punctures; seen from above the horns of head are evenly rounded; four anterior legs reddish........ 3.

3. Posterior orbits uniformly punctured; vertex with large uniform punctures; antennæ rufous.. **D. luzonensis sp. nov.**

Posterior orbits with umbilicate punctures anteriorly, and with fine punctate granulations posteriorly; vertex with depressed area (which is finely granular) extending obliquely and along the line of the projected lateral carina of frontal horn; flagellum piceous. **D. luciliae sp. nov.**

The only species of *Dirhinus* recorded from the Philippines not included in the above key is *D. anthracia* Walker. The original description of this species is so inadequate that the species cannot be placed. The size and color of the antennæ would separate Walker's species from the larger forms here described. The original description of Walker's species is as follows:

Dirhinus anthracia Walker.

Dirhinus anthracia WALKER, List Hym. Brit. Mus., pt. 1 (1846) 8, 85.

Nigra, pedibus rufis, metapedibus nigris, alis limpidis.

Body black, dull, punctured: antennæ black: head clothed beneath with silvery down: tips of the scutellum dentate: abdomen smooth, shining, much shorter than the thorax: legs red; hind legs black: wings limpid; squamulæ and nervures piceous. Length of the body 2 lines; expansion of the wings 2½ lines.

Philippine Islands.

Dirhinus banksi sp. nov.

Female.—Length, 2.5 millimeters. Head above and pronotum coarsely and closely punctured; antenna as in fig. 1, *d;* posterior orbits with large umbilicate punctures; anterior part of scutum shining, but finely reticulate; sides and posterior portion of scutum coarsely punctured with a tendency to striate punctations medianly; scutellum with large punctures except for a large, polished area medianly; propodeum reticulate and with a broad, shallow depression at basal middle; first tergite with four strong longitudinal carinæ; base of second tergite striate medianly; rest of abdomen polished; hind coxæ transversely striate. Black; four anterior tibiæ and femora somewhat marked with piceous; all tarsi yellowish; wings hyaline, venation pale brownish.

Type locality.—Manila, Luzon, Philippine Islands.

Described from two specimens (one type) the sex of which I cannot be sure about, under accession No. 18576, Bureau of Science. Material collected by C. S. Banks and said to be a parasite of *Lucilia* species.

Type.—Catalogue No. 24957, United States National Museum. Left antenna of type mounted on a slide.

Named in honor of Prof. C. S. Banks.

Dirhinus luzonensis sp. nov.

Female.—Length, 4.5 millimeters. Head above with large punctures which are separated by about half their width; posterior orbits with large punctures; antenna as in fig. 1, *e;* pronotum shining, with large separate punctures; scutum shining, with large, elongate punctures at posterior middle; scutellum polished, with large punctures around sides; propodeum finely granular and with reticulations, the middle basal area depressed; first tergite short, smooth, with four rather weak, longitudinal carinæ; basal middle of second segment longitudinally striate; rest of abdomen polished; dorsal aspect of hind coxæ with transverse striæ. Black; antennæ and four anterior legs rufous; tegulæ testaceous; hind tarsi reddish yellow; wings hyaline, venation pale brown.

The paratype is somewhat smaller.

Type locality.—Manila, Luzon, Philippine Islands.

Described from two (one type) females collected by Rev. Robert Brown, S. J.

Type.—Catalogue No. 24958, United States National Museum. Right antenna of type on a slide.

Dirhinus luciliae sp. nov.

Female.—Length, 4 millimeters. Head above with large, close punctures anteriorly, punctures smaller and more widely separated posteriorly; depressed areas on vertex granular and with a few large punctures; posterior orbits with large punctures anteriorly and finely granular posteriorly; antenna as in fig. 1, *a*; pronotum with large, well-separated punctures; lateral lobes of scutum polished; median lobe of scutum finely reticulate anteriorly, posteriorly with large punctures which tend to become confluent; sides of scutellum with large punctures, the central area polished; propodeum irregularly reticulate, basal middle depressed; first tergite with four longitudinal carinæ; base of second tergite striate medianly; rest of abdomen polished; hind coxæ with transverse striæ. Black; four anterior legs rufous; flagellum, tegulæ, and hind tarsi piceous; wings hyaline, venation brown.

In the paratype the hind tarsi are yellowish brown.

Type locality.—Manila, Luzon, Philippine Islands.

Described from two (one type) females under accession No. 18575, Bureau of Science. Material collected and reared by C. S. Banks and said to be a parasite of *Lucilia* species.

Type.—Catalogue No. 24959, United States National Museum. Antenna of type and flagellum of paratype on slides.

Although the available information would suggest that this is related to *D. banksi*, the characters given in the above key should easily distinguish the two.

PERILAMPIDÆ

Genus **NESOPERILAMPUS** novum

This new genus has the general habitus of *Perilampus*, to which it runs in the available keys, but can be distinguished from the old genus by the following key:

Scrobal cavity narrow, well separated from lower margins of eyes; scape compressed; pronotum long; marginal vein much shorter than postmarginal; notauli poorly defined............................ **Nesoperilampus** g. nov.

Scrobal cavity broader and not sharply defined below; scape cylindrical; pronotum short; marginal vein longer than postmarginal; notauli usually well defined.. **Perilampus** Latreille.

Antennæ inserted well above the lower margins of eyes, 13-jointed, scape compressed, one ring joint, club poorly defined and indistinctly 3-jointed; scrobal cavity narrow, pointed above, and sharply defined to lower margin; pronotum about half as long as scutum and sculptured like it; notauli poorly defined; scutellum distinctly longer than scutum, pointed posteriorly, and projecting beyond propodeum; marginal vein much shorter than postmarginal. Black.

Genotype, *Nesoperilampus typicus* sp. nov.

Nesoperilampus typicus sp. nov.

Male.—Length, 3.5 millimeters; length of anterior wing, 3 millimeters. Anterior margin of clypeus broadly, shallowly emarginate medianly; surface of clypeus rather coarsely coriaceous and clothed with long hair; at least sides of scrobal cavity finely aciculate; front (except scrobal cavity) and sides of head with strong dorsoventral rugæ; vertex with strong transverse rugæ; first funicle joint longer than second which is slightly longer than third; club indistinctly 3-jointed; pronotum, scutum, and scutellum with shallow umbilicate punctures; scutellum produced posteriorly into a rather acute triangle, the free edge of which has a broad, deep, shining furrow with the ventral lip

extending narrowly beyond the punctured portion of scutellum; posterior face of propodeum with irregular transverse striæ; mesepisternum largely smooth and shining; sides of propodeum coarsely reticulate; abdomen smooth and polished. Black; funicle, except extreme apex, rufo-ferruginous; apices of tibiæ and all tarsi yellowish; wings hyaline, venation pale brown; hair of head and thorax gray.

Type locality.—Kolambugan, Mindanao, Philippine Islands. Described from one male collected in 1914 by C. S. Banks.

Type.—Catalogue No. 24973, United States National Museum.

Genus **PERILAMPUS** Latreille

Key to certain Oriental species of Perilampus.

1. Base of abdomen opaque, covered with small punctures .... 2.
   Abdomen entirely smooth and shining .... 4.
2. Bright green; area laterad of notauli striate .... **P. singaporensis** sp. nov.
   Dark green or greenish black .... 3.
3. Area laterad of notauli smooth; scutellum distinctly triangular posteriorly and emarginate .... **P. orientalis** sp. nov.
   Area laterad of notauli sculptured; scutellum obtusely subtriangular posteriorly and not emarginate .... **P. punctiventris** Crawford.
4. Dark green; posterior orbits with strong striæ except for a narrow area close to eye .... **P. luzonensis** Crawford.
   Black; posterior orbits except a narrow posterior margin smooth. **P. nesiotes** Crawford.

Perilampus singaporensis sp. nov.

The bright green color separates this species from the other Oriental forms.

Female.—Length, 4 millimeters. Clypeus gently convex, shining, smooth except for a few setigerous punctures, the anterior margin depressed and slightly, broadly, arcuately emarginate; malar furrow distinct; carina defining scrobal cavity dorsally extending ventrally to a point opposite the insertion of antennæ; scrobal cavity sharply angulate dorsally and terminating immediately behind anterior ocellus; area below lateral ocelli with a few raised lines; posterior part of vertex with a few transverse rugæ; posterior orbits smooth, shining except posteriorly where there are a few dorsoventral striæ; funicle wanting; pronotum, scutum (except as mentioned below), and scutellum with large umbilicate punctures; notauli foveolate; area just lateral to notauli shining and with oblique striations; posterior margin of pronotum narrowly truncate, the edge gently upturned and slightly emarginate; posterior face of propodeum

shining, with a median ridge bounded by a rather broad depressed area; base of abdomen subopaque, with fine close punctures. Bright green (including legs to base of tarsi); tarsi ferruginous; wings hyaline, venation brown.

Type locality.—Singapore, Straits Settlements.

Described from a single female received from C. F. Baker.

Type.—Catalogue No. 24974, United States National Museum.

Perilampus orientalis sp. nov.

This species seems to be allied to *Perilampus megalaspis* Cameron but differs in the lack of striæ on the malar space, the absence of white hair on the head, etc.

Female.—Length, 3.75 millimeters. Clypeus gently convex, shining, with a few setigerous punctures, the anterior margin gently rounded out, not depressed; malar furrow distinct; scrobal cavity limited dorsally by a short carina (extending a short distance below ocelli), the rest of the area dorsad of the depression with short striæ which extend ventrally nearly to a point opposite the insertion of antennæ; these striæ do not reach the inner eye margins; lateral areas of frons and vertex shining, without definite sculpture; posterior orbits shining and without sculpture except for a few striæ posteriorly; flagellum stout, first funicle joint a little longer than second; pronotum with three rows of umbilicate punctures; scutum (except as mentioned below) and scutellum with umbilicate punctures; notauli not sharply defined; the area just lateral to notauli shining and without sculpture; scutellum narrow posteriorly and distinctly emarginate; posterior face of propodeum shining, with a median ridge bounded laterally by a foveolate depressed area; base of abdomen subopaque with close, fine punctures. Head and thorax dark metallic green, abdomen blue-black; anterior tarsi pale, other tarsi wanting; wings hyaline, venation pale brown.

Type locality.—Singapore, Straits Settlements.

Described from one female received from C. F. Baker.

Type.—Catalogue No. 24975, United States National Museum.

Perilampus nesiotes Crawford.

A single female from Ilocos Norte, Luzon, collected June 2, 1912, by C. S. Banks and bearing the word "Bangui" on the label agrees very closely with the unique type of the Sumatran species *P. nesiotes* Crawford. The Luzon specimen is a trifle larger, but I see no characters by which it can be separated from the type.

BRACONIDÆ

Bassus cylasovorus sp. nov.

Wings dusky; head, prothorax, and scutum largely rufous; sides of thorax, propodeum, and abdomen largely black.

Female.—Length, 4 millimeters. Head seen from in front but little wider than high; malar space somewhat shorter than the greatest transverse diameter of eye; clypeus truncate apically, convex toward median line; posterior orbits narrow; occiput concave; postocellar line slightly shorter than ocellocular line; head smooth, shining, with only setigerous punctures; antenna longer than head and thorax, 31-jointed; thorax shining; suture before scutellum broad, coarsely granular; propodeum smooth, the central dorsal area coarsely punctate-reticulate, the laterodorsal area punctate; abdomen shining, highly polished; ovipositor slightly longer than abdomen; stigma broad, about 4.5 times as long as broad; radial cell very narrow, the radius curved anteriorly. Black; head except spot surrounding ocelli and reaching bases of antennæ, prothorax, and scutum except a central spot rufous; apical margin of first tergite, base of second, and first two sternites yellowish; four anterior legs reddish yellow; hind legs black except basal three-fourths of tibiæ which are whitish; wings dusky hyaline, venation dark brown.

Male.—Length, 4 millimeters. Besides the usual sexual characters the male differs from the female only as follows: Head and scutum entirely rufous; second and third tergites except a median spot yellowish.

Type locality.—Manila, Philippine Islands.

Described from one female (type) and one male received from C. S. Banks and said to be parasitic on *Cylas turcipennis* Boh. The labels bear the date April 20, 1919, and "A. G. Toquero. L. H. R. 495 Bur. Agr., P. I."

Type.—Catalogue No. 24730, United States National Museum.

Microbracon cylasovorus sp. nov.

Female.—Length, 2.5 millimeters. Head strongly receding behind eyes, polished; ocelli in an equilateral triangle; antennæ almost as long as body, flagellar joints of nearly equal length; prescutum completely defined; notauli not foveolate; mesonotum shining, polished, with rather long sparse hair; posterior part of scutum and anterior part of scutellum with distinct separate punctures; propodeum polished but with a median longitudinal area which is sculptured; sides of first tergite coarsely reticu-

late, the central portion polished; second tergite longitudinally striate-punctate and with an elongate triangular raised and polished area at basal middle; suture between second and third tergites coarsely foveolate; third, fourth, and base of fifth tergites longitudinally striate-punctate, remaining tergites polished; ovipositor extending beyond abdomen a distance subequal with abdomen beyond first tergite; first abscissa of radius subequal with first abscissa of stigma; second abscissa of radius subequal with second abscissa of stigma. Rufous; spot around ocelli, three spots on scutum, propodeum and abdomen piceous; legs reddish yellow; wings hyaline, venation pale brown.

In one paratype the abdomen is almost entirely rufous.

Type locality.—Manila, Philippine Islands.

Described from three females (one type) received from C. S. Banks and said to have been reared from *Cylas turcipennis* Boh. Specimens labeled as collected February 14, 1919, by A. G. Toquero and given No. "L. H. R. 481."

Type.—Catalogue No. 24731, United States National Museum.

Paratype.—Returned to Bureau of Science, Manila.

ILLUSTRATION

[Drawings made by Eleanora Armstrong from slides prepared by S. A. Rohwer.]

TEXT FIGURE

FIG. 1. Antennæ of *Dirhinus* and *Eniaca; a, Dirhinus luciliae* sp. nov. (type); *b, D. excavatus* Dalman (det. Ashmead); *c, Eniaca hesperidumi* Rossi; *d, D. banksi* sp. nov. (type); *e, D. luzonensis* sp. nov. (type); *f, D. auratus* Ashmead, male (det. Ashmead).

PHILIPPINE SPECIES OF THE GENUS PROTHYMA AND OTHER CICINDELINÆ

By WALTHER HORN

Of Berlin-Dahlem, Germany

It has not been possible until recently to obtain a correct idea of the specific values of the various species of *Prothyma* from the Philippine Islands, owing to the fact that the material collected was far too scant. Localities given by Cuming, Semper, and others have but little value. Collecting by Whitehead, Everett, Doherty, Banks, Baker, and Schultze has resulted in obtaining material with exact localities and, consequently, the specific features have begun to clear up.

At various times I have received material from European dealers in insects. Such material is usually not very valuable, as one can place little confidence in the localities mentioned by them.

The result of the study of these collections is that we note a most extraordinary degree of variability within the several species. This makes them still more difficult to study, as the number of characters used for diagnosis has always been very small. Herewith I give a résumé of these characters and the variations that may occur.

Prothyma hopkinsi Horn.

Labrum with the brownish sagittal stripe sometimes well developed, sometimes lacking. The portion bearing the three middle teeth sometimes long and narrow, sometimes short and broad; sagittal tooth of variable length, first segment of antennæ entirely yellow or almost entirely dark metallic, but its dorsal surface frequently dark, its ventral surface distad usually yellow. The frons and vertex are usually metallic coppery, with the antennæ, ocular region, portions of the orbit, and disk of vertex frequently greenish. The pronotum may be longer or shorter, its middle portion usually cylindrical or converging caudad. Dorsal surface moderately or strongly convex, but sometimes quite plane (especially on the caudal half) ; its sculpture fine

or coarse. Some specimens show the pronotum short, roughly sculptured, the sides convergent, and the dorsum flattened caudad. Others show the pronotum longer, cylindrical, finely transversely striated, and strongly convex. The pronotum is usually copper colored, the transverse sulci being bluish or greenish laterad and the lateral borders broadly or narrowly blue. Sometimes the whole cephalic margin of the pronotum is greenish or there is a greenish golden sheen mediad with blue lateral borders cephalad of the posterior margin and caudad of the bluish anterior sulcus. Some specimens show the transverse sulci to be green or golden, some almost entirely copper colored. The elytra may be long or short, the sculpture being sometimes shallow and less confluent in the caudal half; the apical borders have a narrow bluish or greenish stripe, the lateral borders a larger one of dark copper violet, mediad of which on the anterior fifth is a greenish or bluish stripe (which may be entirely obsolete, or may extend caudad to yellow discal patch, or take the form of a diffuse golden stripe near the disk). Occasionally the lateral borders are bluish violet with a green stripe mediad in the first fifth; the lateral borders are sometimes brownish coppery, being lighter near the humeral angle, or the border may differ from the disk only by a more decidedly copper violet hue. The humeral macula is sometimes lacking in the female. The distal spot is short triangular, horizontal or longer or narrower, having an oblique direction toward the disk. Its inner half may be narrowed or equal to the outer. The apical spot may be broad or narrow, sometimes circular, sometimes transversely oval, and not infrequently with its posterior margin concave. All the spots may be white.

LUZON, Laguna Province, Mount Maquiling, Mount Banahao, and Paete: Tayabas Province, Dolores: Bataan Province, Mount Limay.

There are two subspecies of *Prothyma hopkinsi.*

Prothyma hopkinsi subsp. **bakeri** Horn.

This subspecies was originally described as a true species. At first view the fine blue color of the frons, vertex, pronotum, and bases of the elytra, the very convex, rather globose middle portion of the pronotum, the short and on their caudal half less deeply and densely sculptured elytra seem to be quite characteristic, but intermediate forms occur; for example, a specimen from Polillo Island having exactly the same shape and sculpture

as *bakeri*, but with most of the frons, vertex, and pronotal disk coppery. The disk of the elytron in this specimen shows a color intermediate between the forms already described. The blue of the bases of the elytra is very variable (sometimes the base and the lateral areas in the anterior two-fifths are blue; occasionally there is only a broad blue stripe surrounding the whitish humeral macula (all maculæ are whitish in *bakeri*) and extending caudad toward the disk, terminating before the median spot; sometimes the blue has the same distribution as in typical *P. hopkinsi.*

LUZON, Tayabas Province, Malinao.

Prothyma hopkinsi subsp. **rotundato-cuprescens** subsp. nov.

Differt a forma prioritatis sagitalli labri parte infuscata; tota corporis superficie laetius aureo-cuprascente; elytris subnitentibus; capita pronotoque valde splendentibus; pronoto sat convexo; elytrorum maculis testaceis, paullo majoribus; media lata obliqua, multo breviore; ante-apicali plus minusve rotundata; primo antennarum articulo testaceo.

Long 11–12 mm. (sine labro).

Insula Biliran (*McGregor*) a Dom W. Schultze mihi comunicata; ♂ in collectione mea, ♀ in collectione W. Schultze.

The dorsal surface is golden coppery; head and pronotum very brilliant, elytra a little duller, with larger but shorter yellow spots; pronotal sulci greenish blue in their depths. Lateral border of pronotum narrowly greenish or bluish. Borders of elytra dark copper violet, on the first fifth with a greenish or bluish submarginal stripe.

Prothyma lucidicollis Chaud.

The typical *P. lucidicollis* has a strongly globose pronotum, very convex dorsad; rather convex elytra, with moderately confluent sculpture. Frontovertical area and pronotum golden coppery, very brilliant, with fine sculpture intermittently obsolete. *Prothyma heteromallicollis* Horn, described originally as a species, is but a subspecies of *P. lucidicollis*, although the typical form differs as follows: Middle portion of pronotum cylindrical, plane dorsad; elytra less convex, with deep sculpture and with strongly confluent punctures. Dorsal area of frons, vertex, and pronotum dull and densely finely sculptured.

Both of these typical forms are from unrecorded localities in the Philippine Islands.

I have recently received material from Iligan, Agusan, Butuan, and Surigao, Mindanao, and from Biliran Island that shows a variability almost as striking as is shown by *Prothyma hopkinsi,* but all these specimens are mere intermediate forms between the type and my subspecies that may be characterized as follows: Head often bulky and with the occipital portion dull, densely but finely sculptured, dark coppery or lighter cuprescent, with or without greenish blue reflections here and there and with the lateral margin of the vertex broadly greenish or bluish. Pronotum more or less convex, sometimes slightly globose, densely but finely sculptured, semiopaque or brilliantly dark coppery, with a narrow, greenish stripe near the lateral margins; transverse sulci coppery or greenish, occasionally with the whole surface, except the central disk, more or less bluish or greenish and with the four borders broadly greenish. Elytra with a short greenish stripe extending from the humeral angle halfway to the median spot entad of the dark purple-violet margin, which may be lacking. Sculpture of the distal half more or less confluent but never deeply crenulated. Spots yellowish or whitish; middle one sometimes longer or narrower, directed obliquely caudad; anteapical spot frequently slightly prolongated in the direction of the sutural spine.

Subspecies *coerulea* Horn differs from the typical subspecies *heteromallicollis* by being narrower and more elongated, the middle portion of the pronotum being long, parallel sided, plane dorsad, with fine, dense, transverse striations. Segments 2 to 4 of the antennæ almost entirely, tibiæ often, yellow; sculpture of elytra denser, deeper, and more confluent. Middle spot of elytra smaller than anteapical one. Dorsal surface more or less blue.

Prothyma banksi sp. nov.

Species quasdam generis Odontochilae simulans. Fronte interoculos evidenter excavata ibique impressione discoidali in forma "vestigii equi" (postice conclusi) ornata. Elytris impressionibus 5 indistinctis ornatis: 1[a] pone humeros oblique suturam versus directa, 2[a] longitudinali sat longa in disco laterali juxta maculam median, 3[a] parva juxta maculam ante-apicalem, 4[a] parva sed profundiore in angulo suturali, 5[a] longa indistincta levissima juxta suturam posita; dimidia parte postica elytrorum longe et dense (praesertim transversaliter) plicata: rugis valde distinctis.

Long. 14–15 mm. (sine labro).

Insula Panay, Antique, Culasi (*McGregor*) a Dom W. Schultze mihi data: 1 ♀ in collectione mea, 1 ♀ in collectione W. Schultze.

This species differs from *Prothyma hopkinsi* by being larger; labrum dark with an irregular, yellow disk; frons between the eyes with a large central impression; pronotum cylindrical, only slightly convex, densely transversely striate. Elytra slightly more flattened, uneven, with the impressions as described above; more roughly and deeply sculptured throughout. Sculpture crenulate-confluent on apical half (except near the lateral margins where the individual punctures are separated and not deep). The individual crenulations sometimes occupy three-fourths of the width of the elytron; the whole dorsal surface is of a dull, dark brown coppery bronze. Sides of vertex and pronotum bluish green; lateral borders of elytra dark purple-violet, with a short greenish blue submarginal stripe in the basal fourth mediad of the marginal color. There are two or three pale yellow spots on each elytron; a small humeral dot, sometimes lacking, a short oblique middle patch extending to disk and becoming slightly more remote from margin than in *P. hopkinsi.*

Many years ago Prof. Charles S. Banks sent me a male, 13 millimeters in length, of a new *Prothyma,* from the Bureau of Science collection, Mount Canlaon, Negros (800 meters), for study and I have dedicated this new species to him.

The penis of this specimen has, according to my notes, a "plain bulky apex."

Philippine species of the genus Prothyma.

1. Labrum metallic. Small species (8.5 to 9.5 millimeters exclusive of labrum); apex of penis moderately tapering with the tip (turned toward concave side) showing a very short hook directed to concave (left) side. Tibiæ often more or less yellow .... 2.

   Labrum yellow or yellow and dark; a larger species (10.5 to 14 millimeters); apex of penis variable in length. Tip never showing a hook or angle directed toward the concave (left) side. Tibiæ dark metallic .... 4.

2. Dorsum of head and pronotum very brilliant, the sculpture very fine or obsolescent. Pronotum very convex.......... **P. lucidicollis** Chaud.

   Dorsum of head and pronotum not brilliant; their sculpture fine and dense. Pronotum less convex or even plane.......... 3.

3. Pronotum and elytra short. Dorsal surface coppery, with green reflections caudad of humeral angles. Middle spot of elytra not smaller than the anteapical one.... **P. lucidicollis subsp. heteromallicollis** Horn.

   Pronotum and elytra more elongate. Dorsal surface entirely or at least its greater portion blue. Segments 2 to 4 of antennæ often yellow.

Middle spot of elytra smaller than anteapical one. Sculpture of elytra dense, deep, and generally confluent.

P. lucidicollis subsp. **coerulea** Horn.

4. Frons with a deep horseshoe-shaped sulcus between eyes, in center of disk; first four segments of antennæ metallic black. Elytra with undulated surface, each with longitudinal basal impressions.

P. banksi sp. nov.

Frons without horseshoe-shaped discal impression and sulcus; first or third segment of antennæ often more or less yellow or pale brown. Elytra without longitudinal impressions.. 5.

5. First segment of antennæ almost entirely dark metallic. Dorsal surface of third segment almost entirely brownish. Middle portion of pronotum long cylindrical. Lateral half of base of elytra with isolated punctures (not confluent), interstices larger than punctures themselves. Penis with long narrow apex, the tip of which shows a small flattened prolongation on its convex (right) side.

P. schultzei Horn.

First segment of antennæ usually more or less yellow. Dorsal surface of third segment dark metallic, except sometimes at apex. Middle portion of pronotum variable. Basal half of elytra densely intricately punctured. Punctures often slightly confluent. Penis with a very short, bulky, conical apex, the tip of which shows a slight trace of a rectangular prolongation directed toward the convex (right) side.... 6.

6. Middle portion of pronotum variably convex. The whole of the dorsum of the body brownish coppery. Frons, vertex, and pronotum moderately brilliant. Sculpture of the apical half of the elytra dense and slightly confluent. Middle spot of elytra elongate... **P. hopkinsi** Horn.

Middle portion of pronotum rather convex, entire dorsum of body brownish coppery; frons, vertex, and pronotum brilliant; sculpture of apical half of elytra dense and confluent, two posterior spots of elytra yellowish and irregularly rounded.

P. hopkinsi subsp. **rotundato-cuprescens** subsp. nov.

Middle portion of pronotum convex. Dorsum of frons, vertex, and pronotum blue or at least greenish blue coppery. Sculpture of apical half of elytra less dense and only slightly confluent. Middle and posterior spot of elytra whitish and elongate.

P. hopkinsi subsp. **bakeri** Horn.

Among the Cicindelinæ collected by Mr. W. Schultze, of Manila, are to be found a great many very interesting species. They are as follows:

Collyris speciosa Chaud. Mindoro, near Abra de Ilog.

Collyris similior W. Horn. Mindanao, Momungan, and Zamboanga.

Collyris chaudoiri W. Horn. Biliran Island. Punctures on the basal and apical thirds of elytra less dense and of smaller size than usual.

Collyris emarginata. Mindanao, Zamboanga.

Collyris albitarsis.

Tricondyla aptera subsp. *globicollis*. Polillo Island; Mindanao, near Surigao.

Tricondyla cyanipes subsp. *conicicollis* Chaud. Panay, Capiz; Dinagat Islands.

Tricondyla subsp. *elongata* W. Horn. Mindanao, Lanao Province near Iligan.
Tricondyla subsp. *brunnipes* Motsch. Luzon, Benguet Subprovince, Baguio.
Therates fasciatus subsp. *flavilabris* F. Leyte, Tacloban; Samar, Catbalogan; Mindanao.
Eurytarsa beccarii Gestro. Luzon, Benguet Subprovince, Mount Santo Tomas (2,400 meters).
Heptodonta melanopyga Schm. Mindanao, Surigao.
Cicindela virginalis W. Horn. Panay, Antique Province, Culasi.
Cicindela conicollis Schm. Luzon, Benguet Subprovince, near Baguio.
Cicindela mandibularis Schm. Luzon, Laguna Province, near Paete.
Cicindela conspicua Schm. Luzon, Kalinga Subprovince, near Balbalin.
Cicindela fugax Schm. Mindanao, Surigao.
Cicindela clara subsp. *rugothoracica* W. Horn. Luzon, Benguet Subprovince, Pauai (Haight's).
Cicindela excisa Schm. Panay, Capiz Province, Libacao.
Cicindela chlorochila F. Biliran Island.

The species of *Collyris* fly in full sunshine, appearing like small wasps, settling for a short time on leaves and stems of plants where they run about rapidly and again fly away. The species of *Tricondyla* usually run up the bases of tree trunks to the distance of about a meter. Species of the genus *Eurytarsa* are usually found in numbers running around on mossy stones. *Therates fasciatus* may be taken in the half shadows of forests, flying from leaf to leaf. They give off a very pleasant aromatic odor when captured. All the known species of *Prothyma* fly very rapidly at a height of about a meter in the half shadows of damp forests with much undergrowth; here they alight on the leaves. *Cicindela clara* subsp. *rugothoracica* runs and flies rapidly near damp places along roadsides.

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A FEEDING EXPERIMENT ON TWO HUNDRED LEPERS AT CULION LEPER COLONY, PHILIPPINE ISLANDS

By HARTLEY EMBREY

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ONE PLATE

At the request of Governor-General Leonard Wood and Dr. Vicente de Jesus, I organized and conducted a feeding experiment on two hundred lepers at Culion Leper Colony, Philippine Islands.

This feeding work was undertaken for the following reasons: (*a*) The chaulmoogra ethyl ester treatment for leprosy in many respects is not successful with lepers who have syphilis, yaws, or tuberculosis; many of the Culion lepers are tuberculous; (*b*) the Government raw rations now supplied to more than 4,000 lepers at Culion are decidedly insufficient in calorific value, mineral matter, vitamine content, and quantity of protein; (*c*) even the supplies that are given out at Culion are issued in irregular amounts and often at irregular intervals, particularly in the case of fish and vegetables.

The last condition is due largely to the following factors: Culion Leper Colony is located on the rocky coast of an island about 200 miles (320 kilometers) south of Manila. Very little gardening is done by the lepers. The arrival of boats in the past has been irregular, and there is a lack of proper refrigeration in the colony, so that supplies cannot be stored for long periods of time.

The regular Culion diet, as indicated by a table given me by the steward of the colony, follows:

Culion Leper Colony, September 19, 1921.

Standard weekly ration furnished each leper as per last record on file.

6 ounces beef, fresh.
1 loaf bread.
1 kilogram camotes, when available.
0.2 package chocolate (for hospital).
0.75 chupa[1] coffee, green.
1.5 kilograms fish, fresh (0.25 kilogram daily for six days).

[1] A chupa is approximately 200 grams.

0.1 pound lard compound.
0.5 head onion.
14.5 chupas rice, unpolished.
0.75 chupa salt, native.
0.75 chupa sugar, brown.
Vegetables and fresh fruits when available.

The above issues represent an average per capita issued for general ration. Chocolate, etc., are issued monthly, and milk is consumed in hospitals and by young children. This standard ration might be altered by actual circumstances and substituted by the equivalent amount of other food, whenever available, and at the discretion of the chief of the colony. As a matter of fact, the fish supply last year was so irregular that a daily average of only about 100 grams per person was given to between 4,000 and 5,000 lepers.

I have been unable to find any records in medical literature of previous feeding work done in leprosy cases, so that the plan of the diets was based on the following theories:

Since there is a leprotic fever in connection with the disease, also phthisis, and since in all fevers the metabolic processes are increased while at the same time the power of assimilation is diminished, and there is a burning up of body proteins as well as fats, I decided in favor of a high-calorie diet.

Honeij has shown that there is a definite absorption of bone salts in leprosy, and experimental work indicates that in leprosy the organism exhibits a tendency to retain calcium and magnesium, whether the patient is maintained upon a diet containing little or much of these elements; the more advanced the pathological condition, the more evident does this tendency to retention become.

It is therefore conceivable that under dietary conditions in which calcium is not particularly abundant, the lack of this element may play a material part in the rapidity of the progress of disease.(1)

In view of this work, and the recent work on experimental rickets, which shows the remarkable influence of certain substances present in cod-liver oil and also in green vegetables in stimulating the deposition of calcium, I decided in favor of an adequate supply of fresh vegetables and fruits. These would serve the additional purpose of increasing the amount of vitamines and of mineral matter.(2, 3)

To supplement the insufficient fish ration with a cheap available protein, I suggested the use of mungo, *Phaseolus aureus* Roxburgh, a bean which is abundant in the Islands. Previous

analysis and experimental feeding with this bean showed that it contains about 22 per cent of protein, which is of fairly good quality.(4)

The ration shown in Table 1 was worked out as a basal diet, which could be modified as needed.

TABLE 1.—*Daily basal ration, subject to modification, for an adult leper.*

	Protein.	Fat.	Carbohydrate.	Calories.
	g.	*g.*	*g.*	
Unpolished rice, 2 chupas, 400 grams	32	1.2	316.0	1,436
Mungo, 1.5 chupas, 300 grams	66	2.4	176.4	993
Salted pork or fat, 20 grams		20.0		178
Sugar, 25 grams			25.0	100
Fresh native vegetables (from 300 to 400 grams), such as camote, upo, mungo-bean sprout, pechay, camote leaves, gabi, squash, tomato, ube, eggplant, patola, onion, etc., or fruits such as papaya, orange, banana, coconut, etc.				[a]100
Total	98	23.6	517.4	[b]2,807

[a] The calorific value of this item will be from 60 to 300 calories, according to the vegetables or fruits selected.

[b] Approximately.

Children from 8 to 12 years of age were to be given seven-tenths of the amounts prescribed, and in addition one glass of milk a day. Three hundred grams of fish or meat can be substituted for the mungo, but with such substitution the rice ration or the vegetable ration should be increased from 400 to 500 grams. This increase is recommended because neither fish nor lean meat has the calorific value of the mungo bean.

The feeding experiment was conducted only on leper volunteers. In making a choice of applicants the following rules were adhered to in each case: (*a*) Representatives were selected from each province of the Islands; (*b*) lepers were selected in whom the disease was at the medium stage of advancement; (*c*) when all other conditions were the same preference was given to lepers who in the past had depended largely on Government rations. It was believed that this procedure would give a more-striking comparison as to the relative values of the old and the new diets. The applicants pledged themselves to take no food on the outside, but otherwise their regular medical treatment and their usual occupations and habits of living were not altered in any way.

The theater was converted into a large dining room, a card system of entrance was used, and the attendance at each meal was recorded. The weights of the lepers were taken each week.

An open-air kitchen was erected by the side of the theater; several lepers were chosen to assist in preparing the food, and the cooking was done in plain view of the entire colony.

The meals were made as nearly equal from the standpoint of calories as possible. The hours of 7, 12, and 5.30 were chosen for meals.

Table 2 shows the composition of eighteen typical meals, illustrative of the type of food given. Table 3 records the weights of the lepers. Calculation of the calorific value of all of the menus shows an average of 3,145 calories per adult per day, and an average of 2,673 calories per child per day. However, it cannot be asserted that each of the lepers ate the above number of calories per day, since there were no facilities for weighing the food which remained, and the appetites of the lepers naturally were somewhat variable. On the whole, however, their interest in their food was surprisingly constant, and they consumed the larger number of calories without any inconvenience and were apparently improved in energy and spirits.

The average cost, calculated on the prices of the first forty-five meals, was 31 centavos per person per day if milk and coffee are excluded from the calculation, and 35 centavos per day if these items are included. This cost can be greatly reduced without affecting the dietary value of the food, by careful study of the market prices, and selection of the cheaper varieties of proteins, beans, press cakes, vegetables, and fruits.

The main object in this early experimental work was to demonstrate the physiological effects of a better-balanced diet. It was necessary to keep constantly in mind the fact that all the people experimented on were volunteers, sick, and naturally suspicious of any radical innovation.

SUMMARY

This experiment lasted from January 20 to February 24, 1922; of the 200 persons included, 164, or 82 per cent, gained from 100 grams to 5.1 kilograms in weight with an average increase of 2.5 kilograms per person.

Only 14.5 per cent of the patients decreased in weight, with an average decrease of 1.3 kilograms per person; 3.5 per cent remained stationary.

The increase was more frequent in patients under 50 years of age and was almost negligible in patients over 50 years of age.

Lepers in the incipient stage of the disease are more prone to variations. Of the 54 cases composing the incipient group, 90.7 per cent increased in weight, and none remained stationary.

Of the 101 cases forming the middle group, 83.1 per cent gained in weight, and 11.8 per cent lost weight. Of the 45 advanced cases, 68.8 per cent gained weight, and 26.6 per cent lost weight.

While this experiment was not conducted on a rigidly scientific basis, due to lack of proper laboratory facilities, the conclusion seems justified, from the above results, that a high-calorie diet, with an adequate supply of mineral matter, of vitamines, and of that substance found in green vegetables which aids in the deposition of calcium is beneficial to lepers and that their weight and general health are improved thereby.

ACKNOWLEDGMENT

I am deeply indebted to Dr. Jose Avellana, of Culion Leper Colony, for his help in completing the records given below, also to Dr. Vicente de Jesus and Dr. M. Griffin for valuable coöperation.

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TABLE 2.—*Six days' menus, illustrative of the kind and quantity of food given in the experimental feeding of two hundred lepers at Culion Leper Colony, January 21 to 26, 1922.*

JANUARY 21, 1922.						
Food.	Weight.	Protein.	Fat.	Carbohydrate.	Fuel value.	Cost.
Morning.	*Kilos.*	*g.*	*g.*	*g.*	*Calories.*	*Pesos.*
Fish	9.25	1,730	120	101.8	8,232	2.78
Mungo	9.25	2,044.3	74	5,439	30,618	1.76
Pechay	9.5	125	42.5	580	3,287.5	2.50
Eggplant	12.5	133.7	56.2	767.5	5,462.5	5.00
Pork	0.5	9.5	431	----------	4,045	0.50
Onion	0.5	8	1.5	49.5	245	0.08
Sugar	2	----------	----------	2,000	8,000	0.30
Rice	35	2,800	105	27,650	125,650	4.20
		6,850.5	830.2	36,587.8	185,540	16.92
Milk, 25 cans, small size, for children only	----------	363	440	605	7,850	8.75
Coffee	1.5	----------	----------	----------	----------	0.85
		7,213.5	1,270.2	37,192.8	193,390	26.52

TABLE 2.—*Six days' menus, illustrative of the kind and quantity of food given in the experimental feeding of two hundred lepers at Culion Leper Colony, January 21 to 26, 1922*—Continued.

JANUARY 21, 1922.						
Food.	Weight.	Protein.	Fat.	Carbohydrate.	Fuel value.	Cost.
Noon.	*Kilos.*	*g.*	*g.*	*g.*	*Calories.*	*Pesos.*
Mungo	9.25	2,044.3	74	5,439	30,618	1.56
Pechay	14	140	47.6	649.6	3,682	2.80
Eggplant	14	149.8	63	859.6	6,118	5.60
Onion	1	16	3	99	490	0.16
Pork	0.5	9.5	431	----------	4,045	0.50
Lard	1.5	52.5	1,320	----------	12,510	3.38
Rice	35	2,800	105	27,650	125,650	4.20
		5,212.1	2,043.6	34,697.2	183,113	18.20
Night.						
Meat	25	4,750	4,775	----------	63,750	18.50
Green papaya	7	76.3	11.9	259	1,484	1.40
Onion	2	32	6	198	980	0.32
Green pepper	2	----------	----------	----------	----------	0.40
Tomato, 2 cans	----------	24	4	80	460	0.31
Ripe papaya	13	141.7	22.1	481	2,756	2.60
Rice	35	2,800	105	27,650	125,650	4.20
		7,824	4,924	28,668	195,080	27.73
JANUARY 22, 1922.						
Morning.						
Fish	20	3,740	260	220	17,800	6.00
Onion	1	16	3	99	490	0.16
Pepper	1	----------	----------	----------	----------	0.20
Patola	28	176.4	36.4	1,190	5,936	11.20
Rice	35	2,800	105	27,650	125,650	4.20
Sugar	2	----------	----------	2,000	8,000	0.30
		6,732.4	404.4	31,159	157,876	22.06
Milk, 50 glasses, 25 small cans, for children only	----------	363	440	605	7,850	8.75
Coffee	1.5	----------	----------	----------	----------	0.85
		7,095.4	844.4	31,764	165,726	31.66
Noon.						
Beef	20	3,800	3,820	----------	51,000	14.80
Tomato, 2 cans	----------	24	4	80	460	0.31
Onion	2	32	6	198	980	0.32
Pork	0.5	9.5	431	----------	4,045	0.50
Papaya	5	54.5	8.5	185	1,060	1.00
Eggplant	28	299.6	126	1,719.2	12,236	11.20
Lard	2	70	1,760	----------	16,680	4.50
Rice	35	2,800	105	27,650	125,650	4.20
		7,089.6	6,260.5	29,832.2	212,111	36.83

TABLE 2.—*Six days' menus, illustrative of the kind and quantity of food given in the experimental feeding of two hundred lepers at Culion Leper Colony, January 21 to 26, 1922*—Continued.

Food.	Weight.	Protein.	Fat.	Carbohydrate.	Fuel value.	Cost.
JANUARY 22, 1922.						
Night.	*Kilos.*	*g.*	*g.*	*g.*	*Calories.*	*Pesos.*
Mungo	9.25	2,044.3	74	5,439	30,618	1.56
Fish	9.25	1,730	120	101.8	8,232	2.78
Green pepper	2					0.40
Onion	2	32	6	198	980	0.32
Lard	2	70	1,760		16,680	4.50
Pechay	28	280	95.2	1,299.2	7,364	5.60
Rice	35	2,800	105	27,650	125,650	4.20
		6,956.3	2,160.2	34,688	189,524	19.36
JANUARY 23, 1922.						
Morning.						
Fish	20	3,740	260	220	17,800	6.00
Onion	2	32	6	198	980	0.32
Green pepper	0.5					0.10
Lard	2	70	1,760		16,680	4.50
Rice	35	2,800	105	27,650	125,650	4.20
Sugar	4			4,000	16,000	0.60
Coffee	1.5					0.85
		6,642	2,131	32,068	177,110	16.57
Milk, 25 cans, for children only		363	440	605	7,850	8.75
		7,005	2,571	32,673	184,960	25.32
Noon.						
Banana	25	325	150	5,500	25,250	5.50
Lard	2	70	1,760		16,680	4.50
Sugar	1			1,000	4,000	0.15
Rice	35	2,800	105	27,650	125,650	4.20
		3,195	2,015	34,150	171,580	14.35
Night.						
Salmon	18	3,924	2,178		36,180	5.40
Onion	1.5	24	4.5	148.5	735	0.24
Lard	0.5	17.5	440		4,170	1.13
Patola	12.5	78.75	16.25	531.25	2,650	5.00
Eggplant	12.5	133.75	56.25	767.5	5,462.5	5.00
Rice	35	2,800	105	27,650	125,650	4.20
		6,978	2,800	29,097.25	174,847.5	20.97
JANUARY 24, 1922.						
Morning.						
Fish	12	2,244	156	132	10,680	3.60
Upo	20	100	18	668	3,320	3.20
Onion	1	16	3	99	490	0.16
Green pepper	1					0.20
Corn	35	3,220	665	26,390	127,750	5.25
		5,580	842	27,289	142,240	12.41

TABLE 2.—*Six days' menus, illustrative of the kind and quantity of food given in the experimental feeding of two hundred lepers at Culion Leper Colony, January 21 to 26, 1922*—Continued.

Food.	Weight.	Protein.	Fat.	Carbohydrate.	Fuel value.	Cost.
JANUARY 24, 1922.						
Noon.	*Kilos.*	*g.*	*g.*	*g.*	*Calories.*	*Pesos.*
Mungo	18.5	4,088.5	148	10,878	61,235	3.13
Pork	1	19	862	----------	8,090	1.00
Pepper	0.5	----------	----------	----------	----------	0.10
Onion	1	16	3	99	490	0.16
Pechay	2	20	6.8	92.8	526	0.40
Eggplant	2	21.4	9	122.8	874	0.80
Papaya	18	196.2	30.6	666	3,816	3.60
Sugar	1	----------	----------	1,000	4,000	0.15
Rice	35	2,800	105	27,650	125,650	4.20
		7,161.1	1,164.4	40,508.6	204,681	13.54
Night.						
Beef	20	3,800	3,820	----------	51,000	14.80
Gabi	5	64.5	19.5	1,675.5	7,285	1.00
Onion	1	16	3	99	490	0.16
Pepper	0.5	----------	----------	----------	----------	0.10
Pechay	5	50	17	232	1,315	1.00
Eggplant	5	53.5	22.5	307	2,185	2.00
Upo	5	25	4.5	167	830	0.80
Salt	1	----------	----------	----------	----------	0.02
Corn	35	3,220	665	26,390	127,750	5.25
Coconut	10	570	5,060	2,790	60,800	1.20
Sugar	1	----------	----------	1,000	4,000	0.15
		7,799	9,611.5	32,660.5	255,655	26.48
JANUARY 25, 1922.						
Morning.						
Salmon, 39 cans	18	3,924	2,178	----------	36,180	5.40
Onion	1	16	3	99	490	0.16
Pepper	0.5	----------	----------	----------	----------	0.10
Lard	2	70	1,760	----------	16,680	4.50
Pechay	25	250	85	1,160	6,575	5.00
Pork	1	19	862	----------	8,090	1.00
Salt	1	----------	----------	----------	----------	0.02
Sugar	4	----------	----------	4,000	16,000	0.60
Rice	35	2,800	105	27,650	125,650	4.20
		7,079	4,993	32,909	209,665	20.98
Milk, 50 glasses, 25 cans, for children only	----------	363	440	605	7,850	8.75
Coffee	1.5	----------	----------	----------	----------	0.85
		7,442	5,433	33,514	217,515	30.58

TABLE 2.—*Six days' menus, illustrative of the kind and quantity of food given in the experimental feeding of two hundred lepers at Culion Leper Colony, January 21 to 26, 1922*—Continued.

Food.	Weight.	Protein.	Fat.	Carbohydrate.	Fuel value.	Cost.
JANUARY 25, 1922.						
Noon.	*Kilos.*	*g.*	*g.*	*g.*	*Calories.*	*Pesos.*
Salt	1					0.02
Fish	20	3,740	260	220	17,800	6.00
Onion	2	32	6	198	980	0.32
Lard	2	70	1,760		16,680	4.50
Gabi	30	387	117	10,053	43,710	6.00
Squash	8	106.4	34.4	746.4	3,816	1.20
Upo	6	30	5.4	200.4	996	0.96
Pechay	2	20	6.8	92.8	526	0.40
Eggplant	2	21.4	9	122.8	874	0.80
Pepper	1					0.20
Salt	1					0.02
Bread	40	3,680	520	21,240	107,200	8.00
		8,086.8	2,718.6	32,873.4	192,582	28.42
Night.						
Mungo	9	1,989	72	5,292	29,790	1.52
Pepper	0.5					0.10
Squash	8	106.4	34.4	746.4	3,816	1.20
Upo	8	40	7.2	267.2	1,328	1.28
Eggplant	5	53.5	22.5	307	2,185	2.00
Pechay	10	100	34	464	2,630	2.00
Salt	1					0.02
Gabi	20	258	78	6,702	20,140	4.00
Onion	1	16	3	99	490	0.16
Bread	20	1,840	260	10,620	53,600	4.00
		4,393.9	511.1	24,497.6	122,979	16.28
JANUARY 26, 1922.						
Morning.						
Mungo	20	4,420	160	11,760	66,200	3.38
Ubi	10	286	5	2,731	12,420	5.00
Pechay	10	100	34	464	2,630	2.00
Onion	1	16	3	99	490	0.16
Salt	1					0.02
Green pepper	1					0.20
Sugar	4			4,000	16,000	0.60
Rice	35	2,800	105	27,650	125,650	4.25
		7,622	307	46,704	223,390	15.61
Milk, 50 glasses, 25 small cans, for children only		363	440	605	7,850	8.75
Coffee	1.5					0.85
		7,975	747	47,309	231,240	25.21

TABLE 2.—*Six days' menus, illustrative of the kind and quantity of food given in the experimental feeding of two hundred lepers at Culion Leper Colony, January 21 to 26, 1922*—Continued.

JANUARY 26, 1922.

Food.	Weight.	Protein.	Fat.	Carbohydrate.	Fuel value.	Cost.
Noon.	*Kilos.*	*g.*	*g.*	*g.*	*Calories.*	*Pesos.*
Fish	20	3,740	260	220	17,800	6.00
Lard	4	140	3,520	----------	33,360	9.00
Salt	1	----------	----------	----------	----------	0.02
Patola	4	25.2	5.2	170	848	1.60
Upo	10	50	9	334	1,660	1.60
Squash	4	53.2	17.2	373.2	1,908	0.60
Gabi	2	25.8	7.8	670.2	2,914	0.40
Onion	0.5	8	1.5	49.5	245	0.08
Banana	2.5	32.5	15	550	2,525	0.55
Papaya	6	65.4	10.2	222	1,272	1.20
Coconut	2.1	119.7	1,062.6	585.9	12,768	0.25
Sugar	1	----------	----------	1,000	4,000	0.15
Rice	35	2,800	105	27,650	125,650	4.20
		7,059.8	5,013.5	31,824.8	204,950	25.65
Night.						
Mungo	9	1,989	72	5,292	29,790	1.52
Squash	4	53.2	17.2	373.2	1,908	0.60
Eggplant	4	42.8	18	245.6	1,748	1.60
Gabi	1	12.9	3.9	335.1	1,457	0.20
Pechay	5	50	17	232	1,315	1.00
Onion	1	16	3	99	490	0.16
Pepper	1.5	----------	----------	----------	----------	0.30
Salt	1	----------	----------	----------	----------	0.02
Upo	20	100	18	668	3,320	3.20
Lard	4	140	3,520	----------	33,360	9.00
Rice	35	2,800	105	27,650	125,650	4.20
		5,203.9	3,774.1	34,894.9	199,038	21.80

TABLE 3.—*Record of lepers undergoing experimental feeding from January 20 to February 24, 1922, inclusive.*

[Persons dropped were immediately substituted by other individuals.]

No.	Name.	Age.	Sex.	Civil condition.	Occupation.	Height.	Weight. Before experiment.	Weight. After six weeks.	Weight. Increased or Decreased.	Stage of leprosy.	Remarks.
		Yrs.				*m.*	*Kilos.*	*Kilos.*	*Kilos.*		
1	L. Can	18	M	Single	None	1.5	43.5	41.7	—1.8	Advanced	Missed 1 meal.
2	U. Lor	21	M	do	do	1.64	49.7	52.4	2.7	Middle	
3	A. Lua	21	M	do	Laborer	1.58	34.7	38.5	3.8	Advanced	
4	L. Sor	21	M	do	None	1.6	42.7	44.6	1.9	Middle	
5	F. Alf	16	M	do	Laborer	1.6	44.1	45	0.9	do	
6	A. Sun	20	M	do	do	1.54	50.7	49.7	—1	do	Missed 10 meals, dropped February 2; hospital.
7	M. Arg	25	M	do	None	1.57	44.1	46.2	2.1	Advanced	
8	A. Cab	28	M	do	Laborer	1.60	45.9	49.6	3.7	Middle	Dropped February 4, moved to destino.
9	F. Ber	22	M	do	do	1.59	42.5	45.7	3.2	Advanced	Missed 2 meals.
10	N. Sen	17	M	do	None	1.57	41.5	42.7	1.2	Middle	Do.
11	F. Man	38	M	Widower	do	1.57	39.7	38.5	—1.2	Advanced	Dropped February 28; entered hospital.
12	B. Mar	25	M	Married	Laborer	1.50	45.4	48.7	3.3	do	
13	Y. Y. Sia	22	M	Single	Merchant	1.57	51.7	56.7	5	Incipient	Missed 3 meals; indisposed.
14	P. Bil	18	M	do	Waiter	1.54	41.1	43.8	2.7	Middle	
15	V. Buc	48	M	Married	Laborer	1.63	52.7	52.7		Advanced	Missed 2 meals; dropped February 10; destino.
16	S. Gar	19	M	Single	None	1.65	42.6	44.6	2	Advanced	
17	V. de Alc	40	M	Married	do	1.58	54.7	59.3	4.6	Middle	

TABLE 3.—*Record of lepers undergoing experimental feeding from January 20 to February 24, 1922, inclusive*—Ctd.

No.	Name.	Age.	Sex.	Civil condition.	Occupation.	Height.	Weight. Before experiment.	Weight. After six weeks.	Weight. Increased or Decreased.	Stage of leprosy.	Remarks.
		Yrs.				*m.*	*Kilos.*	*Kilos.*	*Kilos.*		
18	G. Abe	28	M	Single	Laborer	1.51	45.7	47.9	2.2	Advanced	
19	F. Pon	22	M	do	do	1.49	36.6	39	2.4	do	Missed 2 meals.
20	P. Buc	21	M	do	None	1.54	45.6	43.7	—1.9	Middle	Missed 2 meals.
21	G. Cab	43	M	Married	Laborer	1.59	45.1	51.8	6.7	do	Missed 1 meal.
22	C. Ave	15	M	Single	Musician	1.48	33.5	36.1	2.6	do	Do.
23	C. Gin	22	M	do	None	1.57	53.2	55.1	1.9	do	
24	T. de Zaf	29	M	Married	do	1.60	49.8	53.9	4.1	Advanced	Missed 3 meals.
25	C. Ven	38	M	do	do	1.47	36.7	39.4	2.7	Middle	Missed 1 meal.
26	L. Alb	35	M	do	do	1.48	37.7	39	1.3	Advanced	Missed 6 meals; dropped January 29; hospital.
27	R. B. Box	32	M	Single	do	1.56	42.9	44.8	1.9	Middle	Missed 3 meals.
28	E. Cab	21	M	do	do	1.58	51.4	55	3.6	Incipient	
29	E. Est	22	M	do	Laborer	1.60	44.7	52.5	7.8	Middle	
30	F. Luc	21	M	do	None	1.61	47.7	49.6	1.9	Incipient	
31	J. Tri	47	M	Married	do	1.65	45.7	52.6	6.9	Middle	Missed 1 meal.
32	J. Ven	38	M	do	Laborer	1.57	42.9	45.4	2.5	Advanced	
33	L. Sin	17	M	Single	None	1.49	38.7	42.1	3.4	Middle	
34	A. Pas	18	M	do	do	1.64	43.4	43.2	—0.2	Incipient	Missed 1 meal.
35	M. Per	35	M	Married	Laborer	1.62	49.1	51.9	2.8	Middle	Missed 2 meals.
36	S. de Gui	37	M	do	do	1.55	49.7	48.7	—1.0	do	Missed 1 meal.
37	J. Jac	25	M	Single	None	1.46	48.7	49.2	0.5	do	
38	P. Zul	37	M	Married	Laborer	1.60	45.7	49.6	3.9	Advanced	Dropped February 8; destino.
39	N. Est	24	M	do	None	1.57	51.7	53.0	1.3	Middle	Missed 2 meals.
40	S. Cru	50	M	do	do	1.55	44.7	43.3	—1.4	Advanced	

41	B. Dig	50	M	do	Laborer	1.62	54.7	55.0	0.3	Middle	Dropped February 3; destino.
42	R. Boo	32	M	do	None	1.63	49.7	51.4	1.7	do	Missed 1 meal.
43	F. All	27	M	do	do	1.60	51.7	51.5	—0.2	do	Missed 1 meal; dropped February 4; hospital.
44	J. Can	24	M	do	do	1.64	50.0	48.8	—1.2	do	Missed 3 meals; dropped.
45	C. Ill	31	M	Single	Laborer	1.51	34.7	37.8	3.1	Advanced	
46	B. Bue	30	M	Married	Carpenter	1.51	44.7	37.8	—6.9	Middle	Missed 13 meals; dropped February 11; hospital.
47	M. Arc	35	M	do	Laborer	1.00	45.7	44,9	—0.8	Advanced	Missed 14 meals; dropped February 2; illness.
48	T. Ray	30	M	do	Shoemaker	1.60	44.5	46.4	1.9	do	Dropped February 13; hospital; missed 15 meals.
49	S. Nol	42	M	do	Laborer	1.62	49.3	53.8	4.5	Middle	
50	A. Can	38	M	do	None	1.52	43.3	47.9	4.6	do	Missed 3 meals.
51	F. Bal	38	M	do	Laborer	1.63	61	63.2	2.2	do	Missed 5 meals; dropped February 5; P. Works.
52	E. Qui	18	M	Single	do	1.63	50.4	52	1.6	do	Missed 1 meal.
53	B. Tap	37	M	Married	Attendant	1.60	46.8	49.4	2.6	Advanced	
54	N. Taa	21	M	Single	Salesman	1.48	49.3	49.2	—0.1	Middle	Missed 19 meals; dropped February 28; hospital.
55	J. Esp	23	M	do	Shoemaker	1.55	49.8	50.8	1	Advanced	Missed 2 meals.
56	M. Bor	23	M	do	None	1.61	46.8	47.3	0.5	Middle	
57	F. Wan	37	M	do	Musician	1.54	39.7	44.5	4.8	Advanced	Missed 2 meals.
58	R. B. Ro	21	M	do	None	1.59	43.3	43.6	0.3	Incipient	
59	F. Lab	25	M	Married	Shoemaker	1.63	55.7	59.3	3.6	do	
60	M. Loz	70	M	do	None	1.56	49.9	54	4.1	Middle	

TABLE 3.—*Record of lepers undergoing experimental feeding from January 20 to February 24, 1922, inclusive*—Ctd.

No.	Name.	Age.	Sex.	Civil condition.	Occupation.	Height.	Weight.			Stage of leprosy.	Remarks.
							Before experiment.	After six weeks.	Increased or Decreased.		
		Yrs.				*m.*	*Kilos.*	*Kilos.*	*Kilos.*		
61	M. Man	50	M	Married	Laborer	1.50	49.7	52.4	2.7	Middle	
62	Q. Fie	33	M	do	None	1.51	54.6	55.3	0.7	Advanced	
63	E. Mul	28	M	do	Attendant	1.60	56.7	55.8	—0.9	Incipient	
64	J. Dav	24	M	Single	None	1.50	51.7	53	1.3	do	
65	F. San	26	M	Married	do	1.59	53.7	52.7	—1	Advanced	Missed 15 meals; dropped February 28; hospital.
66	T. Pag	37	M	Single	do	1.57	43.1	42.3	—0.8	Middle	
67	J. Tre	27	M	Married	Laborer	1.68	54.7	58.9	4.2	Incipient	Missed 1 meal.
68	L. Lam	22	M	Single	None	1.56	44.7	48.4	3.7	Middle	
69	C. Bad	53	M	do	Laborer	1.62	62.7	62.7		do	Dropped February 4; moved to destino.
70	E. Bay	28	M	Widower	Waiter	1.54	42.7	44.2	1.5	Incipient	
71	J. Ron	35	M	Married	Laborer	1.59	60	60		Middle	
72	F. Maz	23	M	Single	do	1.57	44.7	52.4	7.7	Incipient	Missed 1 meal.
73	V. Rey	38	M	Married	None	1.60	49.7	51.5	1.8	Middle	
74	T. Rec	32	M	do	do	1.57	42.8	42.4	—0.4	Advanced	Missed 29 meals; dropped February 17; hospital.
75	R. Rib	44	M	do	Laborer	1.43	49.7	52.2	2.5	Middle	
76	M. Liz	34	M	do	do	1.51	42.7	46.1	3.4	do	Missed 16 meals; dropped February 17; hospital.
77	B. Sol	29	M	Single	do	1.60	44.7	49.8	5.1	do	Missed 10 meals; dropped February 17; hospital.

78	P. Dac	23	M	do	None	1.61	44.7	45.7	1	do	Dropped February 8; hospital.
79	M. Man	42	M	Married	do	1.65	56.6	57.5	0.9	do	
80	B. Ari	28	M	do	do	1.60	51.4	52.5	1.1	do	Missed 2 meals.
81	V. Mer	33	M	do	Musician	1.53	45.7	48.9	3.2	Advanced	Missed 3 meals.
82	A. Dem	22	M	Single	Waiter	1.58	44.7	46.6	1.9	Middle	
83	B. Noc	45	M	Married	None	1.58	54.7	54.7	----------	Advanced	Missed 23 meals; dropped February 3; hospital.
84	J. Faj	20	M	Single	do	1.58	37.9	40.4	2.5	Middle	
85	D. Por	37	M	do	do	1.58	47.2	47	—0.2	do	Missed 10 meals; dropped February 13; destino.
86	C. Ray	30	M	Married	do	1.59	46.6	44.2	—2.4	Advanced	Missed 21 meals; dropped February 17; hospital.
87	S. Iba	25	M	Single	Waiter	1.62	48.7	52.1	3.4	Incipient	
88	D. Pec	31	M	Married	None	1.55	42.3	45.2	2.9	do	
89	A. Gue	50	M	do	do	1.65	57.4	59.6	2.2	Middle	
90	E. Abr	15	M	Single	do	1.54	37.6	41	3.4	Advanced	
91	D. Her	19	M	do	do	1.65	44.7	52.3	7.6	Incipient	
92	F. Per	17	M	do	do	1.53	42.3	43.3	1	Middle	Missed 1 meal.
93	M. Lla	42	M	do	do	1.58	52.3	54.3	2	do	Missed 2 meals.
94	P. For	28	M	do	Tailor	1.63	52.7	53.3	—0.4	do	Dropped February 12, sickly, T. B.?
95	E. Tol	52	M	Married	None	1.59	45.7	46.8	1.1	do	Missed 1 meal.
96	L. Tad	32	M	Single	do	1.52	44.7	49	4.3	Advanced	
97	F. Cal	25	M	do	Laborer	1.60	59.8	59.6	—0.2	do	
98	J. de Ver	25	M	do	None	1.53	57.9	40.4	2.5	Middle	
99	P. de Guz	26	M	do	Shoemaker	1.58	44.4	45.2	0.8	do	Missed 4 meals.
100	T. Pab	23	M	do	None	1.59	38.7	40.3	1.6	Advanced	Missed 8 meals; dropped February 18; sickly.
101	M. Nor	25	M	do	Shoemaker	1.70	51.3	56.3	5	Middle	
102	M. Sev	28	M	Widower	None	1.58	50.8	52.2	1.4	do	

TABLE 3.—*Record of lepers undergoing experimental feeding from January 20 to February 24, 1922, inclusive*—Ctd.

No.	Name.	Age.	Sex.	Civil condition.	Occupation.	Height.	Weight.			Stage of leprosy.	Remarks.
							Before experiment.	After six weeks.	Increased or Decreased.		
		Yrs.				*m.*	*Kilos.*	*Kilos.*	*Kilos.*		
103	A. Ped	31	M	Single	Policeman	1.59	50.7	53.9	3.2	Middle	
104	M. Bai	21	M	do	None	1.64	44.1	48.2	4.1	Advanced	
105	A. Tio	22	M	do	do	1.52	44.3	46.2	1.9	Middle	Missed 2 meals.
106	B. Tra	24	M	Married	Laborer	1.55	44.7	50.3	5.6	do	
107	F. Jip	23	M	do	Tailor	1.61	42.1	43.5	1.4	Incipient	Missed 1 meal.
108	A. Ave	21	M	Single	None	1.50	37.6	40.4	2.8	Advanced	
109	A. Rey	26	M	do	Laborer	1.61	49.7	52.9	3.2	Middle	Missed 3 meals; dropped February 10; lame.
110	L. Sum	15	M	do	do	1.40	33.5	35.4	1.9	do	
111	A. Rey	21	M	do	Musician	1.51	45.7	48.4	2.7	do	Missed 4 meals.
112	E. Kal	53	M	Married	Laborer	1.55	50.7	53.1	—2.4	do	
113	C. Ram	16	M	Single	None	1.53	38.5	40.2	1.7	Advanced	
114	T. Sab	16	M	do	Musician	1.52	40.5	43.4	2.9	Incipient	Missed 2 meals.
115	P. de Jes	21	M	do	Laborer	1.63	43.6	45.9	2.3	Middle	Do.
116	M. Coc	16	M	do	None	1.51	41.3	41.6	0.3	Incipient	Missed 8 meals.
117	S. Esc	15	M	do	do	1.47	30.7	34.4	3.7	Middle	
118	M. Mal	36	M	Married	Laborer	1.63	55.7	57.6	1.9	do	
119	R. Ell	23	M	Single	Musician	1.65	48.7	51.3	2.6	Advanced	
120	B. Reb	25	F	Widow	None	1.41	40.3	42.5	2.2	Middle	
121	M. Rum	50	F	do	do	1.47	40.7	42.7	2	do	
122	P. Pue	35	F	Single	do	1.42	27.6	29.1	1.5	do	
123	E. Ora	30	F	Married	do	1.46	42.7	43.5	0.8	do	
124	A. Sal	38	F	do	do	1.49	41.7	44.6	2.9	do	
125	F. Uga	20	F	do	do	1.40	30.2	33.2	3	do	

126	J. Qui	24	F	Single	do	1.46	39.7	39.9	0.2	do	Dropped February 3, on insistent request.
127	A. Pin	34	F	Married	do	1.51	38.2	40.1	1.9	do	Dropped February 10, on insistent request.
128	M. Bol	65	F	do	Seller	1.50	41.5	46.6	5.1	do	
129	C. Ali	45	F	do	None	1.45	39.7	44.6	4.9	do	
130	J. Mir	70	F	do	do	1.42	42.2	44.5	2.3	do	Missed 2 meals.
131	D. Ros	30	F	do	do	1.44	37.7	37.7		do	Missed 17 meals; dropped February 18.
132	M. Lov	18	F	do	do	1.47	44.7	46.3	1.6	do	Missed 1 meal.
133	A. Gui	37	F	do	do	1.47	40.7	43.4	2.7	Advanced	
134	F. Car	45	F	do	do	1.52	63.7	64.1	0.4	Middle	Missed 2 meals; dropped February 3, on own request.
135	J. Noc	21	F	do	do	1.42	32.7	31.9	—0.8	do	Dropped February 3, on own request.
136	J. Sal	57	F	Widow	do	1.40	32.1	31.4	—0.7	Advanced	
137	E. Cab	26	F	do	Seamstress	1.45	41.1	44.1	3	Middle	
138	S. Seb	50	F	do	None	1.44	29.7	29.8	0.1	do	
139	I. Jug	29	F	do	Seamstress	1.54	48.1	49.5	1.4	do	
140	E. Cli	53	F	do	None	1.42	37.7	37.3	—0.4	Advanced	Missed 12 meals; dropped February 10; hospital.
141	M. Mar	82	F	do	do	1.55	55.7	59.5	3.8	Middle	
142	G. Ube	50	F	do	do	1.51	35.6	36.2	0.6	Advanced	
143	A. Val	66	F	do	do	1.45	34.8	38.5	3.7	Middle	
144	A. Bau	11	M	Boy	do	1.27	21.1	26.1	5	Incipient	
145	B. Tan	14	M	do	do	1.48	33.9	33.8	—0.1	do	Missed 1 meal.
146	M. Puj	13	M	do	do	1.36	27.7	29.9	2.2	Middle	
147	L. Sat	14	M	do	do	1.39	34.7	36.9	2.2	Incipient	
148	J. Riv	14	M	do	do	1.39	30.7	33.2	2.5	Middle	Missed 2 meals.
149	P. Bri	12	M	do	do	1.25	24.7	27.0	2.3	Incipient	Do.
150	R. Ber	11	M	do	do	1.24	20.7	23.4	2.7	do	
151	N. Bao	10	M	do	do	1.21	20.7	23.9	3.2	do	

TABLE 3.—*Record of lepers undergoing experimental feeding from January 20 to February 24, 1922, inclusive*—Ctd.

No.	Name.	Age.	Sex.	Civil condition.	Occupation.	Height.	Weight. Before experiment.	Weight. After six weeks.	Weight. Increased or Decreased.	Stage of leprosy.	Remarks.
		Yrs.				*m.*	*Kilos.*	*Kilos.*	*Kilos.*		
152	B. Bar	11	M	Boy	None	1.29	24.7	26.4	1.7	Incipient	
153	C. Rub	15	M	do	do	1.40	29.7	31.8	2.1	do	
154	D. Pin	7	M	do	do	1.20	19.1	21.0	1.9	do	
155	E. Gim	10	M	do	do	1.16	14.2	16.3	2.1	do	
156	G. Man	9	M	do	do	1.28	20.8	26.0	5.2	do	
157	A. Tay	6	F	Girl	do	1.03	14.7	15.8	1.1	do	
158	I. Yla	7	F	do	do	1.13	15.6	17.3	1.7	do	
159	A. Man	8	F	do	do	1.11	17.5	19.3	1.8	do	
160	M. Sol	12	F	do	do	1.40	27.5	28.8	1.3	do	
161	G. Dun	15	F	do	do	1.41	41.7	43.1	1.4	do	
162	V. Puj	12	F	do	do	1.30	21.7	27.0	5.3	do	
163	L. Enc	15	F	do	do	1.51	35.4	37.6	2.2	do	
164	C. Isa	13	F	do	do	1.40	29,5	32.0	2.5	Advanced	
165	M. Cas	10	F	do	do	1.14	16.8	17.5	0.7	Incipient	
166	B. Rod	11	F	do	do	1.26	20.5	24.1	3.6	do	
167	E. Baj	15	F	do	do	1.40	35.5	32.0	—3.5	do	Dropped February 18; sickly.
168	A. Ser	10	F	do	do	1.16	18.7	19.9	1.2	do	
169	F. Guz	11	F	do	do	1.20	25.6	27.4	1.8	do	
170	I. Bar	12	F	do	do	1.30	19.7	23.5	3.8	Advanced	
171	S. Ide	13	F	do	do	1.58	36.3	37.5	1.2	Middle	
172	A. Cab	12	F	do	do	1.38	29.9	31.8	1.9	Incipient	
173	V. Cab	12	F	do	do	1.35	28.7	30.2	1.5	do	
174	A. Rep	14	F	do	do	1.38	33.7	35.5	1.8	Middle	
175	V. Bag	10	F	do	do	1.26	23.4	24.2	0.8	Incipient	
176	A. Bay	14	F	do	do	1.36	37.7	38.5	0.8	Middle	

177	S. Rol	11	F	do	do	1.32	28.4	29.6	1.2	Incipient	
178	A. Ali	10	F	do	do	1.57	19.7	25.4	5.7	do	
179	P. Bid	13	F	do	do	1.36	25.5	27.1	1.6	do	Missed 1 meal.
180	A. Abe	14	F	do	do	1.26	24.1	25.5	1.4	do	Missed 20 meals; varicella.
181	S. Enc	12	F	do	do	1.29	25.4	24	−1.4	do	Missed 10 meals; sickly.
182	M. Ung	12	F	do	do	1.35	26.7	29.2	2.5	do	
183	J. Med	10	M	Boy	do	1.17	17.1	20.4	3.3	do	
184	F. Ros	13	M	do	do	1.34	27.8	31.6	3.8	Middle	
185	F. Sun	14	M	do	do	1.40	29.1	31.3	2.2	Incipient	
186	F. Bag	13	M	do	do	1.30	24.5	26.4	1.9	Advanced	
187	T. Esp	10	M	do	do	1.15	17.3	18.4	1.1	Incipient	
188	C. Ale	12	M	do	do	1.41	28.5	30.6	2.1	Middle	
189	C. Esc	9	M	do	do	1.38	28.3	31.2	2.9	do	
190	M. Gay	12	M	do	do	1.30	20.7	20.7		do	Missed 20 meals; dropped February 13; hospital.
191	R. Ara	12	M	do	do	1.32	19.7	24.8	5.1	Incipient	
192	G. Car	8	M	do	do	1.20	17.9	19.8	1.9	do	
193	F. Can	12	M	do	do	1.35	28.9	28.3	−0.6	Advanced	
194	N. Res	24	M	Married	Cook	1.44	48.5	48.8	0.3	do	
195	A. Ben	29	M	Single	Waiter	1.49	39.7	42.8	3.1	Middle	
196	L. Bis	24	M	do	do	1.69	45.2	45.6	0.4	do	
197	A. Bis	26	M	do	do	1.61	47.8	48.1	0.3	do	
198	J. Pac	25	M	do	Cook	1.59	66.4	66.4		Advanced	
199	A. Cos	21	M	do	Waiter	1.57	48.5	48.7	0.2	Middle	
200	D. End	24	M	Married	do	1.66	59.7	61.1	1.4	do	

ILLUSTRATION

PLATE 1

FIG. 1. The outdoor leper kitchen erected for the experimental feeding at Culion Leper Colony.

2. Some of the leper children in the feeding experiment.

3. Ensemble of the feeding experiment.

FIG. 1. THE OUTDOOR KITCHEN.

FIG. 2. CHILDREN IN THE FEEDING EXPERIMENT.

FIG. 3. ENSEMBLE OF THE FEEDING EXPERIMENT.

AN INTERESTING NEW WATER STRIDER FROM FORMOSA

By Teiso Esaki

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ONE PLATE

During a trip to Formosa, I made a collection of insects on September 25, 1921, at Sôsan near Taihoku, with Mr. Ryoichi Takahashi, of the section of applied zoölogy, Department of Agriculture, Government Research Institute of Formosa. In the collection I have found a species of the family Gerridæ, interesting both systematically and ecologically. A small number of the same species, moreover, were captured by us at Shinten near Taihoku, several days later; also two specimens, collected by the late I. Nitobe at Kusukusu near Kôshun, were found in the collection kept at the Government Research Institute of Formosa in Taihoku. This insect was subsequently found to be new to science, and to belong to a new genus.

Genus **RHYACOBATES** novum

Head longer than broad between eyes, the latter being moderately emarginate interiorly; portion of head in front of eyes extended and longer than rest of head, almost pentagonal in shape; antennæ not longer than body, with first joint much longer than the three other joints together, second and fourth joints subequal in length, third slightly longer; rostrum scarcely passing anterior coxæ.

Pronotum much shorter than head, anterior margin straight, posterior slightly concave; mesonotum about three times as long as pronotum; anterior femora thickened and longer than tibiæ, the last with a distinct apical spine; intermediate and posterior femora about subequal in length, very slender, a little shorter than twice the length of intermediate tibiæ in the former, while in the latter about three times as long as posterior tibiæ. Intermediate tibiæ with a fringe of long hairs. First intermediate tarsal joint about eight times the length of second; posterior

tarsal joint very short, the second being slightly longer than the first; all these tarsi without claws.

In the female, abdomen with the lateral margins rolled up and sometimes in contact with each other at the central axis, so that the morphological dorsal side of the abdomen is invisible; anal segment forming a thin-walled tubelike structure with lateral sides pointed posteriorly.

Type, *Rhyacobates takahashii* sp. nov.

This genus is somewhat allied to *Jucundus* Distant, but differs from it in the shape of the head, the considerable length of the first joint of the antennæ and of the intermediate and posterior femora, the apical spine of the anterior tibiæ, the fringe of long hairs on the intermediate tibiæ, the structure of the intermediate and posterior tarsi, and the peculiar abdominal structure in the female. Only the apterous form is known.

Rhyacobates takahashii sp. nov. Plate 1.

Head longer than broad between the eyes, dark brown above, pale yellowish brown beneath, with a somewhat fork-shaped central black fascia on vertex which is bifurcate posteriorly; eyes large, prominent, and black, antennæ not longer than body, black, with first joint slightly thicker and much longer than the three other joints together, second and fourth joints subequal in length, third slightly longer; rostrum scarcely passing anterior coxæ, with apex of third segment and entire fourth segment black.

Pronotum much shorter than head, anterior margin straight, posterior slightly concave; shining black above with a large central brown spot touching posterior margin; prosternum pale yellowish brown, posterior lateral sides silver gray pubescent. Meso- and metanotum together somewhat globose, shining black, with a longitudinal dark brown fascia and somewhat indistinct lateral silver gray striæ, posterior ends of striæ somewhat thickened on mesonotum, and a thin silver gray stria on the central axis of metanotum. Meso- and metasternum silver gray, thickly pubescent.

Anterior acetabulæ, coxæ, trochanters, and femora brown; a spot on the acetabulæ, apical end of trochanters, and two longitudinal lines on anterior and lateral sides of femora black; tibiæ and tarsi black, base of former brown. Trochanters coarsely downy; femora very much thickened, much longer than tibiæ, the last with a distinct apical spine; first tarsi distinctly longer

than second in male, and the former almost twice as long as the latter in the female; claws inserted before apex of tarsi. Intermediate and posterior coxæ, trochanters, and basal one-third of femora brown; rest of femora, tibiæ, and tarsi black; intermediate and posterior femora about subequal in length, very long and slender, the former being about twice as long as the intermediate tibiæ and the latter about three times the length of the corresponding ones; intermediate tibiæ with a fine fringe of long hairs, though somewhat indistinct in the dried specimens; tarsi very much thinner than tibiæ, without claws; first intermediate tarsal joint about eight times as long as second; posterior tarsi very short, second joint slightly longer than first.

Abdomen in male somewhat shining black above; apex of genital segment and below brown, the latter somewhat silvery pubescent; in the female the end of abdomen turns upward markedly, the morphological dorsal side scarcely visible, as the ventrolateral sides roll up considerably. The apparent dorsal side except anal segment black with silver pubescence, ventral side and anal segment pale brown with similar pubescence; anal segment thin walled, forming a tubelike structure, its upper margin black and the lateral sides pointed posteriorly. Length of body, male, 6.5 millimeters; female, 9.5.

Holotype, female,[1] captured at Sôsan near Taihoku on September 25, 1921, by T. Esaki, allotopotype, male, paratopotypes, and paraidiotypes from Shinten near Taihoku are all in my collection. There are also two specimens from Kusukusu near Kôshun in the collection of the section of applied zoölogy, Department of Agriculture, Government Research Institute of Formosa in Taihoku.

This species is named in honor of my friend Mr. R. Takahashi, to whom I acknowledge indebtedness for many favors.

This curious water strider was found at first on a very rapid stream in a rocky ravine at Sôzan. The insects glide swiftly on the surface of the water in all directions and are hardly recognizable owing to the disturbance of the water. They look, however, somewhat like whirligig beetles. Some of them were found climbing on the rocks near by. Numbers of specimens in copula were also captured. Numerous examples were found on the Shinten River which is a very much larger stream than

[1] I purposely took a female as holotype, because some important generic characters are represented only in that sex.

the Sôzan. Here also they live on a rapid current, but at Shinten only the males and the nymphs of the last instar were found. The nymphs were not seen at Sôzan.

The considerable length of the first joint of the antennæ and of the intermediate and posterior femora has been acquired in all probability as an adaptation to the habitat of this insect. The fringe of long hairs on the intermediate tibiæ seems of service in keeping the insect from getting wet. This character is also found in *Halobates,* which inhabits the sea. In the females of *Ptilomera,* a similar fringe occurs on the intermediate femora. The peculiar abdominal structure in the female of this insect seems to have some adaptive significance to its life on running water; at copulation the rolled-up lateral margins firmly clasp the abdomen of the mate on the back. The copulatory organs of both sexes are entirely enveloped by the tube-like anal segment of the female. The insects when captured in copula and placed in a small vial continue the act for a fairly long time, contrary to any other species of the Gerridæ known to me.

ILLUSTRATION

PLATE 1. RHYACOBATES TAKAHASHII SP. NOV.

FIG. 1. Female.
2. Head of female, lateral view.
3. Antenna.
4. Anterior leg of female.
5. Intermediate tarsus.
6. Posterior tarsus.
7. Abdomen of male, dorsal view.
8. Hinder part of abdomen of female, lateral view.

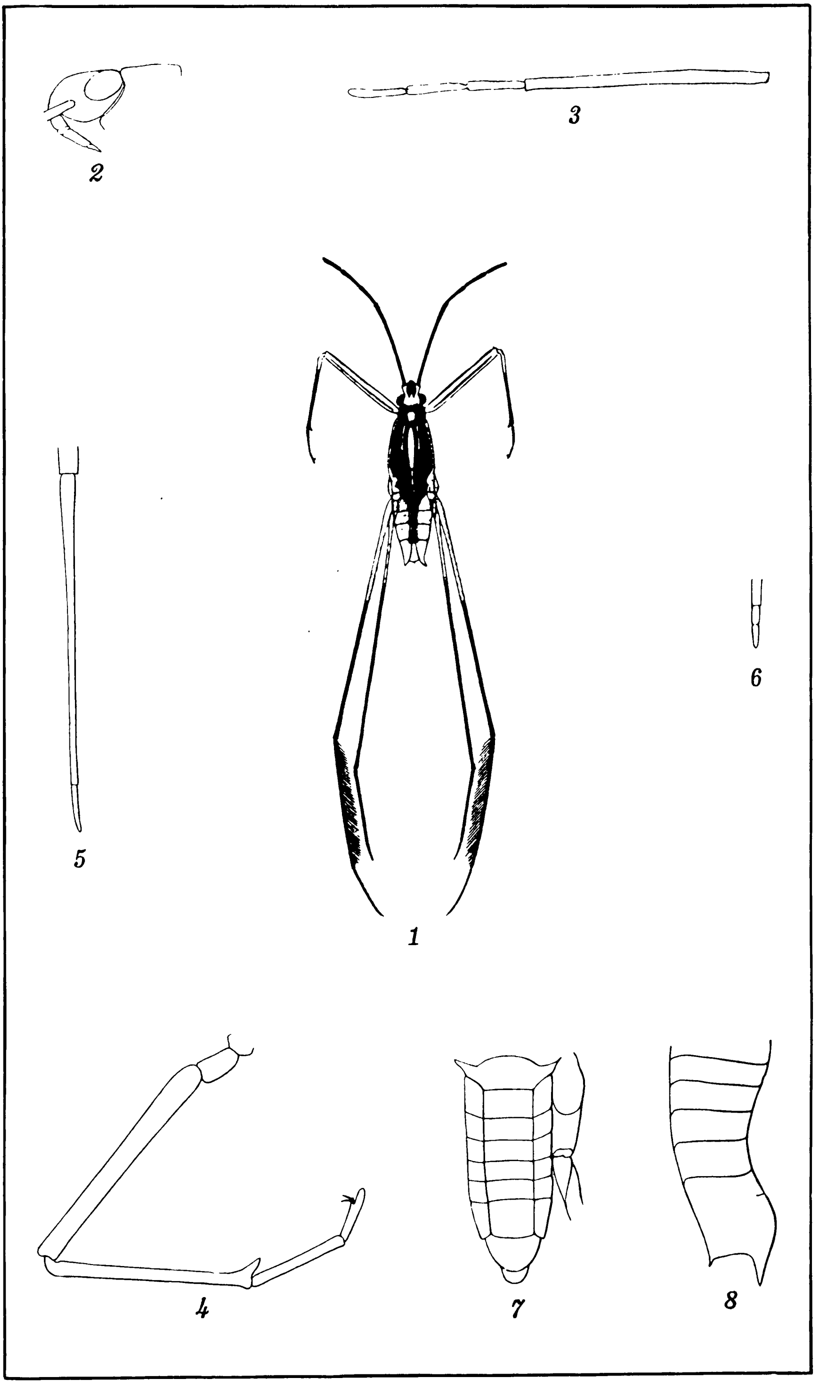

PLATE 1. RHYACOBATES TAKAHASHII G. ET SP. NOV.

THE CHINESE WHITE-WAX SCALE, ERICERUS PELA CHAVANNES

By INOKICHI KUWANA

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TWO PLATES

INTRODUCTION

My attention was first called to the Chinese white-wax scale, *Ericerus pela* Chavannes,[1] during the summer of 1918, and since that time I have had it under more or less continuous observation for two years. The results of the study are recorded in this paper.

Besides the commercial value of its wax product, the insect possesses considerable interest from other points of view, especially that of its biology. Although Sasaki(17) and Yano(20) studied its life history to a considerable extent, the notes published by them on the biology and on the description of the various stages leave many points untouched.

The object of this paper is to present some additional information about the insect, especially as to its morphology. The detailed descriptions of all stages from the egg to the adult, both male and female, were made from living and freshly mounted material collected during the course of the study, and the notes on the life history and habits are from personal observation.

The original material for this study, consisting of females with eggs, was obtained by me at Okudo-mura near Tokyo City, on the branches of *Fraxinus bungeana* var. *pubinervis*, in the early summer of 1918. From these eggs the scale was bred on the same host and on *Ligustrum ibota* in the insectary of the Imperial Plant Quarantine Station at Yokohama. My thanks are due to Mr. K. Katsumata and to the late Mr. K. Kobayashi, who kindly assisted me in the insectary. The figures were drawn by Nobu Kuwana under my direction.

[1] A member of the Coccidæ, subfamily Lecaniinæ (according to Fernald's catalogue(6) it should be Coccinæ).

DESCRIPTIONS

MATURE FORMS

Adult female.—Hemispherical in form, the thoracic region strongly convex and barnaclelike (Plate 2, figs. 14, 15, 16). Average size about 1.2 to 1.5 millimeters in diameter. During pregnancy the body of the female gradually becomes enlarged and at the end of oviposition is nearly globular in form when attached to the host singly, but naturally more or less deformed by mutual pressure when congregated in numbers (Plate 2, fig. 2). The diameter of the largest ones observed was over 10 millimeters. The dorsal surface is dark reddish brown with blackish patches of various sizes over the entire surface. The minute pores are found near the small patches, and from these is excreted the waxy substance that covers the surface. The ventral surface is pale yellow.

The margin of the body is provided with a row of sharp spines, of which the longest observed was about 42 μ. The thoracic incisions are shallow, each with five or more blunt spines (Plate 1, fig. 1, *c*), these being slightly longer than the marginal one and subequal in length. A row of about twenty pores extends from the spiracle to the margin. The mouth parts are well chitinized, with the rostral setæ short. The antennæ and legs are rather small and weak.

The antennæ (Plate 1, fig. 1, *a*) are of six joints,[2] joint 3 the longest and 6 next to the longest, each joint with fine hairs, these being most numerous on the apical joint. The measurements of the antennal joints in microns are as follows:[3]

Joint.		
	μ.	μ.
Second	26	24
Third	45	48
Fourth	21	21
Fifth	21	21
Sixth	36	36

The three pairs of legs are similar in general shape, slender, with a few fine hairs; femora slightly enlarged at the middle

[2] Sasaki (17) states that the young female possesses 8- instead of 6-jointed antennæ.

[3] In this and succeeding tabulations of antennal measurements the length of the first joint is omitted.

portion; tibiæ nearly straight; tarsi tapering apically; claw large and curved; two pairs of conspicuously knobbed digitules (Plate 1, fig. 1, *b*), the pair on the tarsi being the larger. The lengths of the different parts of the hind leg are: Coxa, 60 μ; trochanter and femur, 87 μ; tibia, 72 μ; tarsus, 66 μ; claw, 21 μ. Small pores and fine spiny hairs are sparsely distributed over the dorsum. Anal cleft not deep. Anal plates (Plate 1, fig. 1, *d*) together forming a short oval, almost a circle; the inner margins of the plates are more or less parallel, wavy, but nearly straight, the outer margins almost uniformly curved from base to apex; four dorsal spines near the apex; the ventral surface with six rather long hairs in a row nearly parallel with the inner margin. Anal opening with eight prominent hairs.

Adult male.—Average meaurements: Length of body (exclusive of the style), 2.17 millimeters; width at the thorax, 0.84; antennæ, 1.89; wing expanse, 5; style, 0.48. General color orange yellow with the thoracic region darker; the legs and antennæ pale brown.

Head nearly triangular and bearing six pairs of eyes situated as follows: One large pair on the dorsal side; a smaller pair back of the larger ones; a larger pair, somewhat oval, on the ventral side; and the remaining three pairs, which are small and round, on the sides of the vertex between the larger dorsal and ventral pairs.

Antennæ consisting of ten joints; joint 1 is short and broad, 2 longer than 1 and rather broad, and the others slender; very hairy, the distal joint with three knobbed hairs in addition to the fine ones. The measurements of the antennal joints are as follows:

Joint.				
	μ.	μ.	μ.	μ.
Second	56	60	56	54
Third	266	280	238	252
Fourth	290	280	252	266
Fifth	308	294	280	280
Sixth	322	308	280	280
Seventh	252	252	210	210
Eighth	224	210	196	196
Ninth	154	140	140	140
Tenth	196	112	168	182

The thorax is large, elongate, and much broader than the head; color the same as the head except that the mesothorax

bears two broad purplish brown bands, which lie close to the lateral margins in such a manner as to inclose a nearly hexagonal orange yellow area. The metathorax is marked on its side with an oblique dark brownish streak. Legs rather long, slender, and very hairy; tibiæ very long and nearly twice as long as the femur and bearing a single spine at its distal end; claw long and simple, two pairs of prominent knobbed digitules. The measurements of the different parts of the hind leg are: Coxa, 196 μ; trochanter plus femur, 399 μ; tibia, 756 μ; tarsus, 234 μ; claw, 51 μ. Wings nearly transparent, with costal margin light brown and slightly iridescent; a single vein is present, which begins at the base of the wing and very soon branches, one branch paralleling the costal margin and the other extending toward the anal distal margin. The club-shaped halteres are brownish, and each bears three hooks, which catch in a pocket on the anal margin of the wing.

The abdomen terminates in a pointed style consisting of two long white wax filaments, one arising on each side of the eighth abdominal segment and extending posteriorly. Each of the filaments arises from a number of pores with short spiny hairs and two longer ones, the long hairs being enveloped by the wax filament.

IMMATURE FORMS

The egg.—The eggs are elongate-oval, 0.43 millimeter in length and 0.22 in width. Some are very pale yellow, while others have a slight brownish shade; that is to say, they are slightly deeper in color. The lighter ones produce male larvæ and the darker, female.

The first-stage larva, female.—The body is long-oval in form (Plate 2, fig. 4), widest in the thoracic region, gradually narrowing toward the caudal end, and nearly flat. Pale brownish orange, with the median line dark, the antennæ and legs pale, and the eyes dark brown. Length, 0.60 millimeter; width, 0.36.

After becoming attached to the host the body becomes pale orange gray with white spots at the thoracic incisions, and toward the end of this stage the dorsum becomes more or less convex. Antennæ and legs are comparatively large and slender. The antennæ consist of six joints,[4] each joint bearing a few long hairs, these being most numerous on the apical joint; joint

[4] Sasaki (17) states that the antennæ of newly hatched larvæ consist of eight joints, instead of six as stated in the present paper.

6 is the longest, 3 next to the longest, 4 and 5 subequal, and joint 1 the shortest. The measurements are as follows:

Joint.				
	μ.	μ.	μ.	μ.
Second	18	20	21	18
Third	39	39	35	42
Fourth	15	15	18	18
Fifth	18	18	18	15
Sixth	39	39	39	48

The three pairs of legs are similar; the tibiæ slightly longer than the tarsi; claws large and simple, with the digitules large and knobbed. The measurements of the different parts of the hind leg are: Coxa, 41 μ; trochanter and femur, 67 μ; tibia, 64 μ; tarsus, 45 μ; claw, 24 μ.

The margin of the body bears fine spiny hairs which are longer toward the abdominal end; thoracic incisions with two blunt tracheal spines about 12 μ in length, and usually with three or four pores between the spiracles and the margin. Anal plates with a long apical hair and a few spiny ones near the base, the former measuring about 270 μ. The anal opening bears six hairs.

The second-stage larva, female.—The body is ovate in outline, the thoracic region being the broadest and tapering gradually toward both ends; dorsum more or less convex and the median line raised. Thoracic incisions slight and the anal cleft deep. Pale yellow with the median line yellow; eyes dark brown; the region of the anal cleft pale brown; the legs and antennæ pale. After the insect becomes settled on the host the color becomes pale yellowish green with the margins somewhat purple. Before the second molt takes place the body becomes much convex and the marginal waxy filaments prominent, the longer ones measured being about 0.2 millimeter. The body measures at this time 1.2 to 1.3 millimeters.

Antennæ 6-jointed, joint 3 being the longest, and each bears fine hairs (Plate 1, fig. 2, *a*). The measurements are as follows:

Joint.				
	μ.	μ.	μ.	μ.
Second	18	18	15	18
Third	38	39	39	39
Fourth	18	18	21	21
Fifth	18	17	21	21
Sixth	33	33	36	33

The legs are similar, but the anterior pairs much shorter. The measurements of the different parts of the hind leg are: Coxa, 51 μ; trochanter plus femur, 78 μ; tibia, 69 μ; tarsus, 60 μ; claw, 21 μ.

The margin of the body bears a continuous row of rather short spines, truncate at the apex, and measuring a maximum of 18 μ in length. Thoracic incisions (Plate 1, fig. 2, *b*) normally with four spines, which are slightly longer than the marginal ones, the apex of these spines being blunt as in the adult. About ten small circular pores occur between the spiracles and the body margin. The anal plates are similar to those of the adult female in general shape, with a distinct apical spine. The anal ring bears eight hairs.

The first-stage larva, male.—Similar to that of the female, but somewhat broader (Plate 2, fig. 3). Legs and antennæ stouter, the latter 6-jointed (Plate 1, fig. 3, *a*). Marginal spines (Plate 1, fig. 3,*b*) as in the female, but those of the thoracic incisions fine hairs (Plate 1, fig. 3, *c*) instead of blunt spines.

The second-stage larva, male.—General shape broadly oval (Plate 2, figs. 5, 6, 7, 8), widening in the abdominal region. Antennæ and legs small and weak. Antennæ 7- instead of 6-jointed [5] (Plate 1, fig. 4, *a*) as in the female.

The measurements of the different joints are as follows:

Joint.				
	μ.	μ.	μ.	μ.
Second	18	21	21	21
Third	33	33	30	33
Fourth	15	18	21	20
Fifth	21	21	21	29
Sixth	21	21	21	21
Seventh	39	33	36	37

The body margin with fine hairs, much fewer than in the preceding stage. The thoracic incisions with two sharp spiny hairs (Plate 1, fig. 4, *b*), and the dorsal surface with numerous small pores. Other characters are similar to those of the female.

Immediately before [6] the second molt the body becomes plump,

[5] Sasaki (17) states that the antennæ at this stage consist of three joints only.

[6] The third stage of Sasaki (17) is really the second-stage larva just before the molt. Fig. 10 of Yano (20) appears to me to be also the second-stage larva just before the molt, rather than the third.

glassy, and pale yellow, and is completely covered with the white wax.

The propupa, male.—Following the second molt the male larva assumes the form of a partly developed pupa, called the propupa. The form is oval, with the abdominal region broadest and distinctly segmented (Plate 2, figs. 9, 10). Length, 2.11 millimeters; width, 1.10. The head and thorax are pale orange yellow; the eyes are reddish orange. The posterior end of the body is slightly darker. The antennæ are short, reaching to the base of the anterior legs, and the segmentation is indistinct. Wing pads short, curving a little toward the underside of the body, the apex reaching to the second abdominal segment. Anterior legs very short, reaching to the suture between the thorax and the head, while the two posterior pairs lie against the abdomen. Mouth parts wanting.

The pupa, male.—With the third molt the male becomes a true pupa (Plate 2, figs. 11, 12), greatly resembling the adult male except for the lack of the waxy anal filaments and the possession of wing pads instead of wings. The general color is pale orange with dark purple eye spots, the margins of these being indistinct; antennæ, legs, and wing pads somewhat paler. Antennæ indistinctly 10-jointed and long, reaching to the base of the middle pair of legs. The wing pads are appressed to the sides of the body and extend posteriorly to the second abdominal segment. Legs slender, the anterior pair extending beyond the head, and the posterior pair to near the tip of the abdomen. Mouth parts wanting. Length, 2.49 millimeters; width, 1.08.

LIFE HISTORY AND HABITS

About the end of August the insect is very conspicuous on the branches of *Fraxinus bungeana* var. *pubinervis* growing along the footpaths between the rice fields about Tokyo City; it is particularly noticeable at this time because of the white waxy mass formed by the males (Plate 2, fig. 13). The fully matured female is a large globular object (Plate 2, fig. 2) and firmly attached to the branch, but its color is not striking.

There is but one generation a year. The first female larvæ appear about June 15 from eggs laid some two months previously beneath the mother, where they are hidden from view. The eggs are elongate-oval and somewhat deeper in color than those which produce males. Usually the young remain under the protection of the parent scale for a few days after hatching. The newly hatched young is soft and feeble, but becomes hard

and active when ready to crawl out from beneath the shell of the mother. The larvæ become very active soon after emergence and begin searching for a suitable place at which to feed. All immediately crawl upward onto the leaves where they become attached on the upper surface (Plate 2, fig. 1, *a*). They settle along the veins and do not congregate in groups. As feeding commences there is a noticeable increase in size, and within a few days the dorsal surface becomes covered with a white woolly substance. At the end of the first stage the larva molts, the cast skin being pushed backward off the tip of the abdomen. About a month is required to complete the first stage.

The first molt occurs about the middle of July, after which the insects descend to the naked branches, the majority of them settling on the freshly grown twigs, but some also on branches two or three years old. The insects remain in this stage until about the latter part of August or early September, and after the second molt takes place the adult stage is reached. The female is a sessile object with the dorsum somewhat extended into a cone and flattened ventrally, and the color is greenish yellow with close grayish bands on the thoracic surface. Diameter, about 1.5 millimeters. The antennæ are 6-jointed, as in the previous stages.

A few days after the female larvæ have emerged, the young males come out from beneath the mother, these having hatched from the eggs of lighter color. The male larvæ crawl upward to the leaves and settle in clusters on the undersurfaces (Plate 2, fig. 1, *b*), thus differing in habit from the females. The antennæ of the male consist of six joints, as in the female. Within two days the body is covered with a white woolly secretion.

The first molt takes place about the same time as that of the female or possibly a few days previously, the larvæ then descending to the 2- or 3-year-old twigs and settling on the underside (Plate 2, fig. 1, *c*), then commencing immediately the deposition of wax. Within two or three days the dorsal surface of the mass of insects is nearly concealed by this wax, and about ten days later the bodies are completely embedded in a thick mass of the substance. The thickness of this wax is about 6 to 7 millimeters. The deposit is always heaviest on the underside of the branch, but often extends entirely around it. Before the second molt the body becomes very plump and stands at right angles to the branch, being attached thereto by the mouth parts.

The second molt having taken place, the larva is transformed to a propupa. The male from now on is without mouth parts, and during the dormant period is an inactive creature, able only to move its front legs feebly and to wriggle the abdomen when disturbed. After four or five days the third molt takes place and the pupa appears, this greatly resembling the adult male. As in the preceding stage, it is inactive. About the same length of time is required for this stage as for the preceding one.

When the pupal skin is cast the wings of the male are extended to their full length and then folded, one over the other, upon its back. As soon as the wax filaments have grown to their full length, which requires one or two days, the male backs out of the cocoon, or wax case, and becomes active. It immediately begins searching for a female with which to mate. The life of the adult male is very short, and death occurs soon after mating.

After mating the body of the female increases gradually in size, but not very noticeably until the winter is over. In January of the following year the diameter is about 4 millimeters, and in March the dorsal surface becomes much developed in a hemispherical form and about 6 to 8 millimeters in diameter. The color becomes dark reddish brown with black spots. In the middle of April the deposition of eggs is begun. In early May the body becomes globular and *Kermes*-like in appearance and brownish in color. At this time oviposition is completed and the heavily chitinized skin is nothing but a protecting shell over the eggs.

Each female is capable of laying a great number of eggs, the greatest number under a single female recorded by me being 15,028 and the smallest, 3,372. The egg stage is rather long, the eggs laid in the latter part of April beginning to hatch about the middle of June; that is to say, the incubation period requires about two months.

The proportion of male and female young was not well determined, but in one instance I isolated 1,000 eggs from a single female and kept them in a glass jar for rearing. In this series the proportion was 355 females to 645 males.

FOOD PLANTS

The following plants are recorded as hosts of *Ericerus pela* in Japan:

Chionanthus retusens L. and P. (Hitotsubatago.)
Fraxinus bungeana DC. var. *pubinervis* Wg. (Toneriko.)
Fraxinus longicuspis S. and Z. (Koba no toneriko.)

Ligustrum ibota Sub. (Ibota.)
Ligustrum japonicum Thunb. (Nezumimochi.)
Ligustrum medium F. and S. (Obaibota.)

It appears to me that *Ligustrum ibota* and *Fraxinus bungeana* var. *pubinervis* are the two plants on which the scale is commonly found about Tokyo, and commercial wax production is principally obtained upon the last-named plant. In Kiushu, however, I found it upon *Ligustrum japonicum.* In China(19) the scale is cultivated on *Ligustrum lucidum* Sit. and on *Fraxinus chinensis.* I collected the scale upon the former in a park at Shanghai which I visited en route to Japan after a trip to the South Sea Islands and India in 1921.

NATURAL ENEMIES

According to Sasaki(17) there is an encyrtid parasite (*Encyrtus* sp.) that attacks the scale, and Yano(20) states that *Brachytarsus niveovariegatus* Roelofs attacks the female scale heavily, while *Chilocorus similis* Rossi and *C. tristis* Fold. often attack the larvæ. He also mentions a species of Cecidomyidæ bred from the female scale. Unfortunately, I have not had the opportunity to study the natural enemies of this scale.

ECONOMIC IMPORTANCE OF THE WAX PRODUCT

Ericerus pela is not cultivated in Japan for the purpose of wax production, although the scale develops freely on *Ligustrum ibota, Fraxinus bungeana* var. *pubinervis,* and other plants in the wild state, and peasants often collect the wax in the autumn for the market. The raw wax product is sold in drug stores under the name of *ibota-ro* and is commonly employed as a polish on furniture and other woodwork.

In western China, however, the production of insect white wax has been a most important industry for centuries. About the end of August the white coating is scraped from the branches of *Fraxinus chinensis* and *Ligustrum lucidum* and thrown into boiling water, in which the wax melts and floats to the surface. It is collected by being skimmed off, and while in a plastic state is molded into thick saucerlike cakes. The wax is colorless and inodorous, tasteless, brittle, and readily pulverizes at 60° F. It is slightly soluble in alcohol and dissolves with great facility in naphtha, out of which fluid it may be crystallized. It melts at about 180° F., is lighter than water, and is said to harden by long immersion in cold water. This insect white wax is largely used in the manufacture of candles and in paper glazing, but it is also used in medicine shops as a coating for pills, and is itself

supposed to possess medicinal properties. It is also employed as a polish for furniture, etc. According to Wilson (19) the annual output varies considerably, the industry being almost entirely dependent upon climatic conditions. In poor seasons 50,000 piculs is an average crop, whereas in favorable years more than double this quantity is produced. In spite of the increased consumption of foreign candles and kerosene oils the demand for insect white wax remains steady, and the industry concerned with its production shows very few signs of decline. Owing chiefly to difficulties in navigation on the Yangtsze and consequent heavy freight charges, foreign goods are very expensive and enjoyed only by the wealthy. With the advent of railways vast changes will certainly take place, and this interesting insect-wax industry may at some future date become extinct.

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ILLUSTRATIONS

PLATE 1.

FIG. 1. *Ericerus pela*, adult female; *a*, antenna; *b*, part of hind leg; *c*, spiracular and marginal spines; *d*, anal plates, left from above, right from lower.

2. *Ericerus pela*, second larval stage, female; *a*, antenna; *b*, spiracular and marginal spines.

3. *Ericerus pela*, first larval stage, male; *a*, antenna; *b*, spiracular and marginal spines; *c*, posterior apex of abdomen, showing anal plates and marginal hairs.

4. *Ericerus pela*, second larval stage, male; *a*, antenna; *b*, spiracular and marginal spines.

PLATE 2. ERICERUS PELA CHAVANNES

[All figures except 1, 2, and 13 are greatly magnified.]

FIG. 1. Branch of *Ligustrum* with young larvæ; about natural size. *a*, newly hatched larvæ, female; *b*, newly hatched larvæ, male; *c*, second stage larvæ, male.

2. Branch of *Fraxinus bungeana* var. *pubinervis* with adult females; about natural size.
3. Male, first larval stage.
4. Female, first larval stage.
5. Male, second larval stage, dorsal view.
6. Male, second larval stage, ventral view.
7. Male, second larval stage, lateral view.
8. Second stage larva of male, just before molt.
9. Propupa, dorsal view.
10. Propupa, ventral view.
11. Pupa, dorsal view.
12. Pupa, ventral view.
13. Group of cocoons with white wax; natural size.
14. Adult female in winter, dorsal view.
15. Adult female in winter, ventral view.
16. Adult female in winter, lateral view.

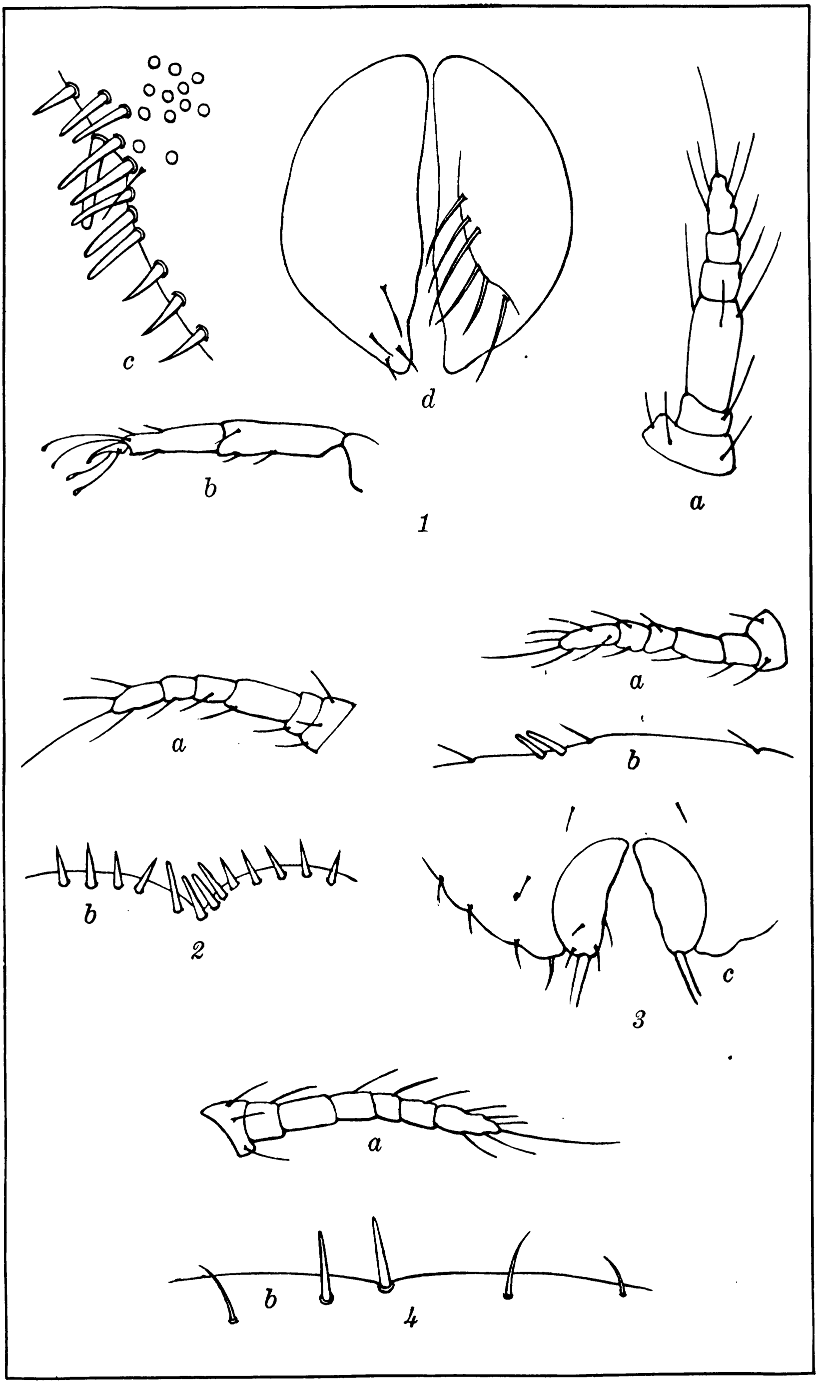

PLATE 1.

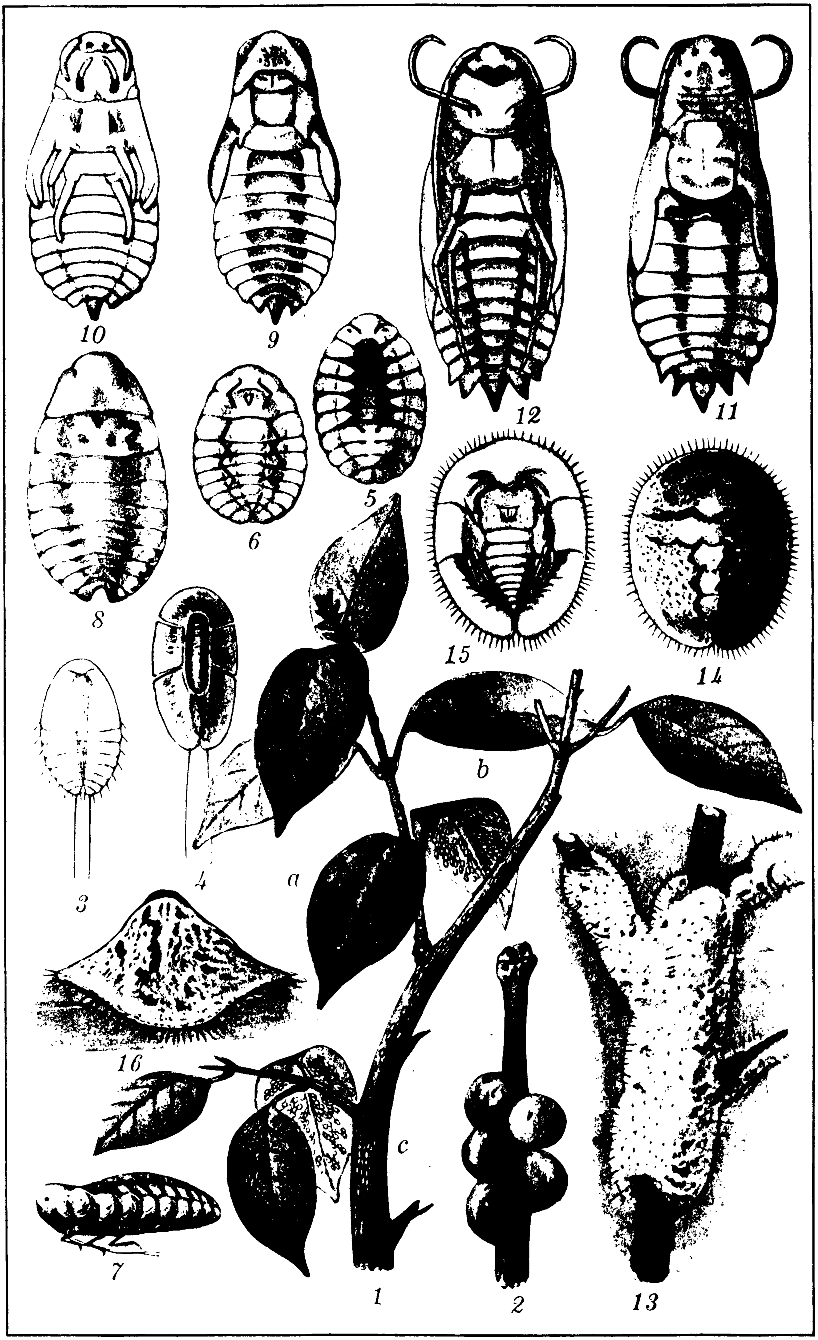

PLATE 2.

A METHOD OF ILLUSTRATING INSECT WINGS

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ONE PLATE

In the preparaton of articles dealing with insect taxonomy, the delineation of insect wings often becomes a serious problem to the entomologist who lacks skill in draftsmanship or does not have available the services of a trained artist. This becomes a decided handicap or a real menace to accuracy in certain orders and families where venation is complicated and where so much depends, especially in generic characterizations, upon minute differences in size or direction of certain veins.

While inked camera lucida tracings are very satisfactory for those wings small enough to come within the field of the microscope, their preparation imposes to too great an extent upon the patience and steadiness of the one making them. In the case of larger wings, the shifting of the specimen and the making of tracings in sections to be united afterwards not only cost time and much labor but also are not infrequently causes of grave errors not at the time perceived by the worker.

Recourse may be had, in many cases, to photography in its ordinary phases and this, supplemented by photomicrography, naturally gives the most-accurate and pleasing results.

It was in casting about for a simplification of the photographic process that it occurred to me to try another method of reproduction, one which has been used with effect for other objects. This was to make a contact negative of the specimen the reproduction of which was desired, and from this negative to make a series of bromide enlargements of any convenient size.

The process by which these reproductions are made requires first that the wing be removed from the insect. It is then laid out, with others which it is desired to reproduce, upon a piece of glass, 12.5 by 20 centimeters (5 by 8 inches), preferably a flawless photographic plate from which the negative emulsion has been removed. After being properly arranged the wing base is touched with a drop of thick white shellac which, when it

dries, secures the wing to the glass in the position desired. The slight opacity of the shellac will leave a mark on the finished enlargement hardly perceptible if the work be carefully done.

The plate is then put into a dust-proof box, where it is left for a day or two in order that the shellac may dry thoroughly, and it is then ready for the next step. This consists in putting it into a printing frame, superimposing a fresh, non-halation, orthochromatic plate, and exposing it for the brief period necessary.

It will be found upon examining the dried negative that every vein, except those in the most opaque wings of certain Tipulidæ, is as distinct as could be desired and any pattern that may appear on the wing membrane detracts but little from the clarity of the venation. From this negative the bromide enlargement can be made with results as good as or better than those shown in the accompanying plate.

The same results are obtainable with wings of Hymenoptera, Neuroptera, Orthoptera, and especially Odonata, the actual drawing of the wings and veins of which is a bugaboo to any entomological draftsman.

With Lepidoptera and Culicidæ the problem is slightly more complicated but resolves itself, in both cases, into removing the scales or making them transparent by Comstock's method.[1]

Although somewhat tedious in specimens of these two groups, the work is well repaid by the accurate and pleasing results obtained and, since in most cases the wings of the Lepidoptera must be denuded or made transparent before drawing them, anyhow, the time saved is quite sufficient to warrant this procedure with them.

Insects such as Coleoptera, Sphingidæ, and certain Rhopalocera which have a thick costa can be treated by a skillful photographer in such a manner as to obviate over- or underexposure of any portion.

When the enlargement has been prepared, it can be used as a base and the venation can be inked in by the draftsman with greatest ease.

I have also found in the course of my experimentation that other parts of insects (legs, antennæ, mouth parts, and even body segments when preserved in balsam on slides) can be re-

[1] Comstock, J. H., and Needham, J. G., The wings of insects, Am. Nat. **32–33** (1898–99).

produced in the same way, provided they be not so small that the photographic emulsion fails to get outline or detail.

Of course the artist will spurn this quick method of reproduction; but, as opposed to many of the painful attempts of some of our entomolgists who do not possess the divine gift, it will be found that this method is calculated to give infinitely more pleasure to those who must look at the finished work.

In the accompanying plate specimens are shown from the most delicately transparent to the most opaque wings obtainable and yet all, except perhaps fig. 10, give practically all the venation details necessary for taxonomic purposes. It will be noted that none of the figures has been retouched in the least.

This method can be and undoubtedly has been applied to the making of prints from such objects as skeletonized leaves, thin rock sections, bone sections, handwriting, and manufactured articles such as laces, woven fabrics, etc.

191652——5

ILLUSTRATION

PLATE 1. Wings of Tipulidæ taken at random, to show ease of reproduction in specimens from the most transparent to the most opaque. These were all made on the same plate at the same time, and neither the negative nor the print has been retouched.

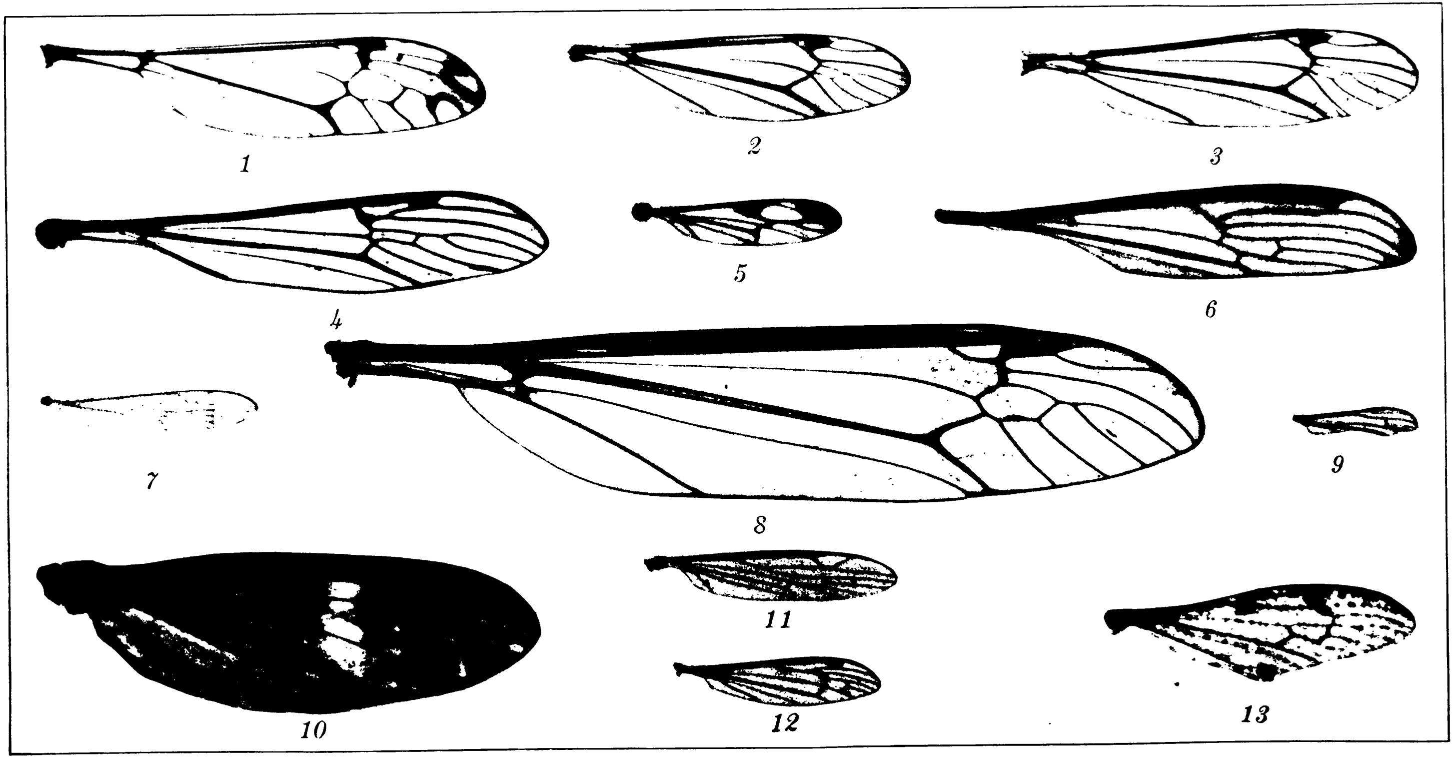

PLATE 1. WINGS OF TIPULIDÆ, TO SHOW REPRODUCTION.

HISTOPATHOLOGY OF THE INTESTINE IN CHOLERA

By Ernest W. Goodpasture

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ONE PLATE

The final diagnosis of cholera rests upon the demonstration of agglutinable vibrios; nevertheless, during an epidemic the pathologist can recognize the disease post mortem in the majority of cases by gross anatomical appearances, although no distinctive single lesion has yet been described. The diagnosis is arrived at by weighing the evidence of a group of changes which are commonly found in typical instances. Crowell(1) has summarized these features as follows: An acute catarrhal enteritis associated with cyanotic finger nails, dry tissues, oligæmia; dry and sticky peritoneum with pink serosa of ileum; contracted and empty urinary bladder; shrunken, dry spleen and liver; acute degeneration of parenchymatous organs; poorly coagulated blood; absence of formed fæces; presence of rice-water intestinal content; and prominence of lymphoid tissue in the ileum.

The mucous membrane of the small intestine presents no characteristic anatomical change but varies in appearance depending on the course of the disease. It is described by Koch(4) as showing in different necropsies all transitions, from a moderate swelling and clouding of the superficial layers and rose red color to a more intense swelling and reddening with extensive loss of epithelium and, finally, to a blue-black discoloration, numerous hæmorrhages, superficial necroses, and even diphtheritic changes.

In a recent small outbreak of cholera in Manila all these variations in appearance of the intestine were encountered at necropsy and an equal diversity in the character of intestinal content, varying from a relatively small amount of greenish, bile-stained, mucus-containing fluid to a voluminous, purplish, blood-stained, watery material with mucus and desquamated epithelium in suspension. In some instances as much as 2 liters of fluid was present in the bowel. The wall of the small intes-

tine, especially the duodenum and jejunum, seemed lax and flaccid, often considerably distended by fluid, suggesting the appearance in paralytic ileus.

This condition of the intestine obviously makes more difficult the problem of securing material suitable for histological study, for the mucosa of a normal intestine rapidly undergoes post-mortem changes, so that the ordinary necropsy specimen is unsatisfactory for histological purposes.

To this difficulty in securing suitable fresh material are due undoubtedly our lack of an adequate description of the histopathology of the intestine in cholera and the differences of opinion on certain points such as whether desquamation of epithelium occurs to any extent before death, as maintained by Deyke,(2) or whether denuding of the mucosa, which everyone describes, is a result of post-mortem maceration, a view advocated by Cohnheim and others.

A complete knowledge of the histopathology of the intestine in early stages would probably throw some light on the obscure pathogenesis of cholera, which appears to be different in principle from any other acute infectious disease. The nature of the intoxicating substance is still in question, and it is yet to be determined whether the intestinal manifestations are due directly to injurious action of a poisonous substance on the mucosa or whether the intestinal congestion, excretion, and anatomical changes are manifestations of the general intoxication. Of special interest is the question of possible desquamation or extensive injury of epithelium which may permit a rapid absorption of toxic material from the intestinal contents.

In a series of cases from San Lazaro Hospital, Manila, which I recently had an opportunity to study, special care was taken in examinations of the intestine. From twenty-five necropsies performed after various intervals it was soon evident that no very reliable information could be gained from material obtained as long as two hours after death. In some instances it was possible to remove the intestine and fix portions of it in less than one hour after death. In one early case on opening the peritoneal cavity slow contractions of the small intestine could be elicited by mechanical stimulation. Such material was very well preserved and its histopathology is worthy of description.

The earliest case was a female Filipino child that was admitted to San Lazaro Hospital at 11.45 a. m., January 12, 1922, and died at 2.10 p. m., January 13. Duration of illness on admission three days. Condition on admission very weak and

drowsy, with abdominal pain and loose bowel movements. Illness began suddenly with loose black discharge. Much vomiting since onset and patient refused to take anything by mouth. Even water could not be tolerated. Child was quiet but apparently conscious. Eyes slightly sunken, face pale, tongue coated, pulse rapid, feeble, thready, and barely perceptible. Extremities cold but not cyanotic. Urinated only twice since onset. Temperature on admission, 36.9° C.; twelve hours later, 36°. Pulse, 85; twelve hours later, 144. Respiration, 23; twelve hours later, 31. Although treatment was immediately instituted the child did not respond well and died twenty-six hours after admission, or four days after the onset.

At autopsy the small intestine was faintly pink. It contained about 100 cubic centimeters of fluid with much mucus stained green with bile. The mucosa appeared velvety and pale. Portions of stomach, duodenum, jejunum, ileum, and colon were immediately placed in formol-Zenker. There was infection with ascaris and with trichuris. Clinically and pathologically it was a typical case of cholera, and cultures from intestinal contents showed the presence of agglutinable vibrios.

Blocks from the gastrointestinal tract were embedded in paraffin and sections stained with hæmatoxylin and eosin and by the fuchsin method for bacteria.(3)

Mucous membrane of the stomach appears normal. Fixation is excellent and there is no evidence of degenerative change even of the superficial cells. The mucosa of the colon shows no lesions except those due to the threading of trichuris through superficial layers in the cæcum. There is, however, a definite pathological change throughout the small intestine, increasing in severity from the duodenum downward.

The mucosa of the duodenum is intact and well preserved, although there is a great subepithelial œdema which has lifted up the epithelial layer, completely separating it from the mucosa except for a delicate honeycomb of lines which seem to represent a continuation of the outline of each cell. The basement membrane remains attached to the mucosa, the fluid apparently accumulating just beneath the cellular body pushing it upward from its basal attachment. The effect of this œdema has been to increase the length of villi by about one-half and the width of the mucosa about one-third. The epithelial layer is intact everywhere except on the crests of valvulæ conniventes where it is broken in places, evidently in the process of preparation, for often the detached layer of cells remains close by. The epi-

thelial cells show no obvious degenerative change; the striated cuticular border is well preserved, the cytoplasm and nucleus compact, staining normally. The number of goblet cells is perhaps increased. Mitotic figures are frequent but not more conspicuous than in a normal intestine.

The mucosa is swollen, especially its papillary projections into villi where intercellular spaces are globular in shape and much exaggerated in size. There is a moderate congestion of capillaries in villi and to a lesser extent of veins in the mucosa and submucosa elsewhere. Larger lymphatics are also prominent and filled with the granular precipitate of a lymph probably of high protein content. No hæmorrhage or cellular exudate is to be seen. There is, however, a very peculiar necrosis of cells within and upon the tips of villous projections of mucosa. This is to be found in nearly every villus and is more prominent in the ileum than in the duodenum and the jejunum. It appears as a karyorrhexis of one or more nuclei of uncertain type, sometimes free, often within large phagocytic cells which may plug capillaries at the apex of villi. This necrosis is sometimes seen along the side of a villus but is found with striking uniformity in the tips. An occasional polymorphonuclear or mononuclear leucocyte is caught wandering through a villus, and usually there are a few small mononuclear cells within the subepithelial spaces. At no point is there necrosis of all cells, and capillary endothelium is intact. The cells that become necrotic appear to lie between capillaries and under or upon the basement membrane of epithelium.

The condition of jejunal mucosa is about the same as that of the duodenal. In the ileum desquamation of epithelium is much more prominent, especially in the lower portions. However, in places where the epithelial layer is still well preserved, subepithelial œdema is present, elevating the cells considerably above the basement membrane but to a less extent than in the duodenum or the jejunum. It is to be noted also that villi denuded of their epithelium differ in no way otherwise from those over which an epithelial coat is still present. There is no more congestion of capillaries, interstitial œdema or necrosis, a fact which appears incompatible with the view that desquamation occurred earlier than the agonal state. The apical necrosis in villi is more prominent than in upper portions of the bowel, and phagocytosis of dead cells is more active. Lymphoid follicles in the submucosa are compact, and show neither necrosis nor abnormal proliferative activity.

In sections stained for bacteria no vibrios could be demonstrated in the duodenum or the jejunum. No organisms of any kind were seen within glandular crypts or beneath the epithelium. In the ileum, on the other hand, especially in the lower portion, an abundant surface growth of various types of bacteria was present and many of these organisms had penetrated the mucosa to a certain extent beneath the elevated epithelium and within denuded villi. They had, however, apparently caused no injury or reaction. Glandular crypts were often filled with bacilli of unrecognized type. In the abundant surface growth of bacilli, cocci, and filamentous forms, no vibrios were identified. Vibrios of unmistakable morphology were found only in glandular crypts, where they lay in great numbers embedded in a film secretion, and often apparently in pure culture. The epithelium immediately around these organisms showed no indication of injury as a result of their presence, and the vibrios exhibited no tendency to invade the tissues.

The most-striking change observable in these preparations in well-preserved portions of the intestine was the subepithelial œdema, which was undoubtedly responsible indirectly for the widespread desquamation of epithelium.

A second case, that of an adult male Japanese, autopsied within two hours after death, shows early post-mortem changes in the epithelial layer and in contrast to them the beginning of antemortem ulceration.

The patient, a man aged 45 years, was admitted to the hospital on the second day of the disease complaining of cramps in the lower extremities, chest oppression, hardly perceptible pulse, and husky voice. Clinically he had cholera, and the bacteriological examination of his stool showed agglutinable vibrios. He developed uræmia and died on the ninth day of the disease.

At autopsy he was found to have very large congenital cystic kidneys, which microscopically showed foci of necrosis involving cortical parenchyma. The small intestine was congested, and the mucosa showed in gross no evidence of ulceration. Pieces were placed immediately in formol-Zenker.

Microscopically, sections through the ileum show the usual subepithelial œdema with as yet very little desquamation. The epithelial layer is partially well preserved, but in many places, especially at the crests of villi, post-mortem changes are very evident, both in the epithelium and in the tips of villous projec-

tions. There are karyolysis and faintly staining cytoplasm, although the outlines of cells are in position. In places where the process of disintegration is more advanced, there are complete disappearance of nuclei and dissolution and softening of epithelium with dislodgment of fragments, leaving the tips of villi denuded; but there is no inflammatory reaction in these places. Overlying such areas is an abundant growth of bacilli, giving the impression that they are partially responsible for this rapid disintegration; rarely, however, are they found within subepithelial spaces, and then only where epithelium has disappeared at some point.

In contrast to this evident post-mortem disintegration there are minute areas of ulceration, obviously ante mortem, for there is necrosis of epithelium, fibrin thrombi in capillaries and veins, as well as polymorphonuclear and epithelioid cell infiltration. In the superficial necrosis there is a sharply limited zone of bacilli having the morphology of *Bacillus coli,* and these bacilli are evidently responsible for the lesion. In the preparations no vibrios are demonstrable on the surface, in the lesions, or within glandular crypts. Had this intestine been examined an hour or so later there would undoubtedly have been extensive desquamation and the areas of ulceration could easily have been overlooked. Agglutinable vibrios were demonstrated in cultures post mortem.

It seems almost too obvious for further consideration that, if ulceration occur in cholera before the agonal period, an inflammatory reaction will appear which can be easily identified. Yet a third case in this series, autopsied one hour and fifteen minutes after death, showed even more strikingly evidences of ante-mortem necrosis of epithelium and ulceration due certainly in part to the local action of vibrios.

This case also was an adult Japanese. The patient, a male, aged 28 years, was admitted to the hospital three hours after the onset of illness. He was in complete collapse, pulse hardly perceptible, extremities cold, with clammy perspiration and cramps. Bowels had moved twice; stools watery in character. The diagnosis, clinically and bacteriologically, was cholera. He died on the sixth day of illness, showing toward the end indications of uræmia. On opening the peritoneal cavity one hour and fifteen minutes after death the upper portion of the small intestine was found to be tremendously distended with gas and

fluid. The duodenum and jejunum measured 6 centimeters in diameter. There was no free fluid in the peritoneal cavity. Loops of jejunum and upper ileum were bound together by thin fibrinous adhesions. In the wall of the jejunum and extending about halfway down the ileum were several large areas of opaque yellowish and greenish necrosis which tended to extend circularly around the gut. The necrosis was most marked opposite the mesenteric attachment. No perforation had occurred, but fibrino-purulent exudate was abundant in the regions of necrosis. The intestinal wall was œdematous, injected, and contained numerous small hæmorrhages. The lower end of the ileum was about normal in size. There was no evidence of mechanical obstruction. The stomach was considerably dilated, especially by gas. No necroses were observed in its wall.

Anatomical diagnosis: Acute enteritis (cholera); dynamic ileus; necrosis of jejunal and iliac walls; acute peritonitis; parenchymatous degeneration of kidneys, liver, and heart.

Microscopically, sections from the upper part of the small intestine show necrosis of the wall and ulceration of mucosa. The submucosa generally is extremely œdematous, and rugæ and villi are flattened because of excessive dilatation. Beyond areas of ulceration the epithelium is well preserved and shows no post-mortem change or desquamation. There is an abundant coating of mucus and there are fragments of necrotic mucosa over the surface, especially between folds. Over the peritoneal surface is a thin fibrinous membrane. In areas of ulceration there is superficial necrosis, polymorphonuclear leucocytic exudate, intercellular fibrin, thrombosis of some small vessels, and congestion of others. In stained sections enormous numbers of bacteria of various types are found in the mucous coat and on the surface of ulcerated areas. The majority of these are short, easily stained bacilli, and thin filamentous forms. In some places, however, masses of smaller, less intensely staining, curved rods are present, morphologically identical with cholera vibrios. The various organisms occur in dense groups so that one type may be easily distinguished from another. No bacteria are found in glandular crypts or invading the mucosa except at the site of ulceration. On the surface of ulcers and for a certain distance within the inflammatory exudate are small curved vibrios, apparently in pure culture. The morphology of these organisms is so distinct that there can be little doubt they are vibrios of cholera.

DISCUSSION

Until the relation of vibrios to the inflammatory process in the third case was observed, it seemed to me very doubtful that vibrios of cholera were ever directly responsible for intestinal ulceration. Evidently they are capable of invading tissue locally and inciting an acute inflammatory process with polymorphonuclear leucocytic exudate. This fact is of importance for understanding the pathology of the intestine in cholera and is suggestive with respect to the pathogenesis of the disease. Since cholera vibrios are capable of tissue invasion and the production of ulceration and inflammatory exudate, it seems obvious that, if desquamation of epithelium occurred to any extent ante mortem, the pathology of the intestine would be very different from what it is found to be, unless desquamation is always followed by immediate death before inflammatory reaction can occur. We would expect to find an acute ulcerative enteritis the typical lesion, but this is the exception, and practically always late in the disease after reaction has begun. The finding of desquamated epithelium in cholera stools means ulceration of the mucosa if the patient survives.

The evidence at hand indicates that it is the growth of vibrios within the lumen of the small intestine that is directly or indirectly responsible for the production of intoxication, and if toxic substances are formed in the intestine they are at first absorbed through a mucous membrane which is anatomically intact except for œdema.

Whether the constant subepithelial œdema is caused by direct action of injurious intestinal material or is a result of splanchnic congestion associated with general intoxication is an open question. Experimental evidence shows the possibility that the latter may be the correct explanation.

Toxic protein products, such as those derived from closed duodenal loops in experimental intestinal obstruction in dogs, when injected intravenously into dogs cause a profound splanchnic congestion, especially of the upper portions of the small intestine, associated with a rapid excretion of intestinal fluid. Histologically, the congested intestinal mucosa shows a similar accumulation of fluid beneath the epithelial layer which becomes elevated, especially over the villi, to a degree equal to that found in the intestine of cholera, and this change is also most marked in the duodenum and the jejunum. The presence of fluid here represents apparently a phase in the great excretory activity of the intestine. The necrosis of a few cells at the tips of the

villi in the first case may possibly be due to direct action of absorbed toxic material, but it is not constant and, in the absence of degenerative changes in the overlying epithelium, it seems more probable that some local condition within the villi is responsible for it. It is not a progressive degenerative change, and the necrotic cells are rapidly phagocytized. MacCallum(5) speaks of a widespread necrosis of the intestinal epithelium in cholera. This I have not seen.

In the presence of subepithelial œdema disconnecting the epithelial sheet from its basement membrane it can be readily understood how the least mechanical disturbance or post-mortem maceration would be sufficient to strip off this layer, especially from the more-exposed folds and villous projections. Even after the tissue is fixed the utmost care is necessary in embedding to prevent its removal. Preparations from the intestine of an executed criminal used for comparative study, fixed within one hour after death, show many denuded villi, evidently the result of mechanical dislodgment.

However, the abundant surface growth of intestinal bacteria with penetration of some of these organisms beneath the epithelial coat and into the tissue of villi in the lower portions of the ileum, as demonstrated in the first case, cannot be attributed altogether to post-mortem activity, and the desquamation of epithelium here is out of proportion to that in the duodenum and the jejunum; yet in this case there is no necrosis of epithelium nor indication of inflammatory reaction. Patients dying of cholera may lie in a moribund state with barely perceptible pulse for some time before death. The child (case 1) under consideration was in this dying state for at least two hours. Under such conditions active growth of intestinal bacteria, especially in the lower ileum, and the presence of digestive enzymes in the intestinal fluid would seem sufficient to macerate the projecting epithelial layer so that it may soften and fall away, thus admitting bacteria whose penetration and growth can no longer elicit an inflammatory response. In fact, this was shown in case 2, but it is not a part of the disease; it is the beginning of disintegration.

That ulceration of intestinal mucosa can occur in the course of the disease is evident from the presence of desquamated epithelium in the stools during life and the occurrence of diphtheritic enteritis or even necrosis of the intestinal wall post mortem. This must be regarded, however, as a complication and not a part of the pathology of typical cholera.

The habitat of vibrios in most cases of cholera is within the intestinal lumen; and, while a few organisms may survive entrance into the blood stream, most of them are no doubt rapidly destroyed. Judging from post-mortem appearances of the intestine, where evidences of their pathogenic nature should be most prominent, the symptoms of cholera are induced by the production, within the lumen of the small bowel, of material which is absorbed through a non-ulcerated mucosa, manifesting its poisonous character by a general intoxication. The œdema of the intestinal wall seems to be a part of the systemic reaction, with splanchnic dilatation, and excretion of quantities of fluid. Finally, there is no indubitable anatomical evidence that in cholera there are changes in the intestinal mucous membrane which would render it more permeable than the normal intestine.

SUMMARY

1. There is a constant subepithelial œdema in the small intestine of cholera subjects, which may be due to splanchnic congestion associated with general intoxication rather than to direct injury of toxic material within the lumen.

2. Desquamation of epithelium in the small intestine as seen at necropsy is an agonal or post-mortem effect due to the action of bacteria and, possibly, of enzymes of intestinal fluid upon the epithelial layer displaced during life by œdema.

3. Ante-mortem desquamation may occur but can be recognized at necropsy by the presence of ulcers with acute inflammatory exudate.

4. The vibrios of cholera may invade the mucosa and be directly responsible for an acute ulcerative enteritis, but they are not always the cause of intestinal ulcers complicating the disease.

5. Anatomical evidence indicates that the great mass of vibrios is confined to the intestinal lumen and, if toxic substances are formed there directly or indirectly as a result of their growth, they are absorbed early in the disease through an anatomically intact mucosa.

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ILLUSTRATION

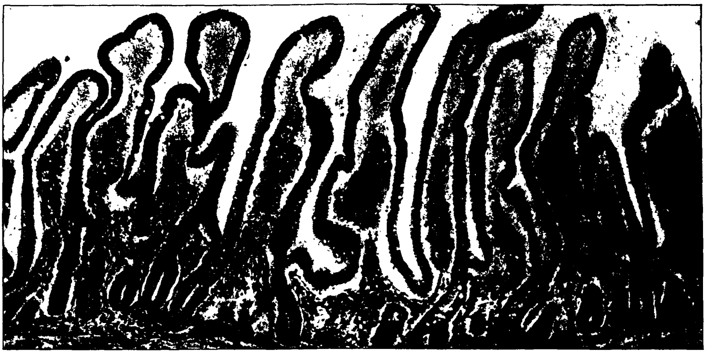
PLATE 1. THE INTESTINE IN CHOLERA

FIG. 1. Section of jejunum from case 1, forty-five minutes post mortem, showing subepithelial œdema, but well-preserved epithelial layer.

2. Section from ileum, case 2, showing subepithelial œdema and beginning post-mortem maceration. Note absence of nuclei at tips of villi and rupture of epithelial layer.

3. More-advanced maceration in case 2.

4. An area in jejunal ulcer in case 3, showing polymorphonuclear leucocytic exudate and vibrios.



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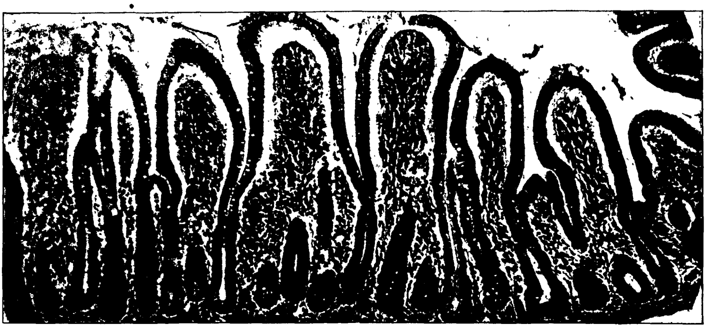

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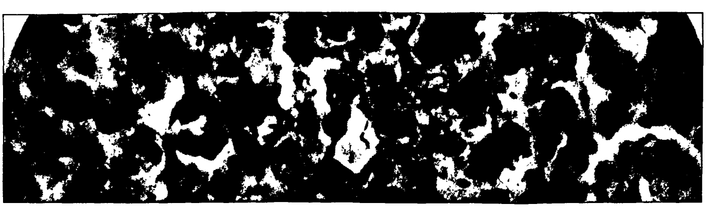

4

PLATE 1.

COMPLEMENT FIXATION IN TREATED AND UNTREATED LEPROSY

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Recently the Philippine Health Service has decreased the period of compulsory detention of lepers to six months after they have become bacteriologically negative; discharged lepers are required to report for observation and treatment periodically. The reduction of the detention period from two years to six months has been made, not on the assumption that these sufferers from leprosy have been cured, but from a belief that they are no longer a menace to the community, and in the hope that, with less-rigid restriction, cases will present themselves earlier for treatment. Even with the great hope held out by the results of treatment with chaulmoogra oil such changes in policy must at the present time be tentative and must be dictated by considerations of expediency, because there do not exist to-day means of determining either that a complete cure has been effected or what extent of improvement is necessary before a leper can be considered as no longer a source of infection.

Undoubtedly, in chaulmoogra oil and its products a most-promising means of combating leprosy on a large scale is at hand. This fact makes more apparent than ever the lack of methods for controlling its use and for more accurately individualizing treatment, without which the success of therapy, especially on such a scale as now practiced at the Culion Leper Colony, will be greatly hampered. Evidences of clinical improvement and the disappearance of demonstrable acid-fast bacilli from accessible parts are of utmost importance, but it is evident that more definite and measurable data are desirable; and improvements in therapy must be accompanied by laboratory investigations to establish methods for proper control, so that the largest measure of success may be attained.

In the present paper observations are presented which, though incomplete and on too small a scale to be final, at least indicate definitely the possibility of utilizing immunological methods

helpfully in conjunction with clinical and bacteriological means in arriving at a more-accurate knowledge of the effect of treatment in individual cases.

Investigations have been conducted with a view of observing the effect of treatment with chaulmoogra oil and its products on complement-fixation reactions with serum of lepers, using various antigens, and the results may be described in two groups; namely, those with lipoidal antigens and those with bacterial suspensions.

WASSERMANN REACTION IN LEPROSY

It has been known for some years that positive Wassermann reaction is obtained in a considerable proportion of cases of leprosy, and that the percentage is higher in the nodular type than in the anæsthetic. Recently Cooke(2) has carefully tabulated the reported cases, 1,397 in all at the time of his publication, including both types. In 50 per cent of these positive reaction was obtained. Seven hundred twenty-three cases were reported to be of the nodular and mixed variety, and in this group 60 per cent were positive; 405 were purely anæsthetic cases, and only 25 per cent of these gave positive reaction.

The presence of positive Wassermann reaction in leprosy cannot be attributed to coincident syphilitic infection, as has been sufficiently proven by unselected groups of controls, as well as on clinical and therapeutic evidence.

METHOD

The Wassermann test was performed according to the details described by Hinton.(4) In the hæmolytic system 2 units of antisheep amboceptor, 0.5 cubic centimeter of a 5 per cent suspension of washed sheep cells, brought to the original volume of whole blood, and 2 units of guinea-pig serum complement were used in each test. The uniformity of sheep-cell suspension was controlled by a color standard, and sera from several pigs were pooled to obtain a complement of uniform strength. A maximum of 0.1 cubic centimeter of patient's heated serum was used in each test and a control of 0.2 cubic centimeter for anticomplementary action. Only one antigen was employed, instead of three as practiced by Hinton. The tests were made with a cholesterinized alcoholic extract of guinea-pig's heart used in doses of 0.1 cubic centimeter of a 1 + 4 dilution. This

antigen was not anticomplementary with twice the amount used in the test. Normal and syphilitic sera were used as controls. In interpreting the results, both with lipoidal antigen and with bacterial suspensions, 4+ indicates no hæmolysis; 3+, faint hæmolysis; 2+, strong hæmolysis; and 1+, almost complete hæmolysis.

For a comparative study of the reaction in untreated and treated cases three groups were selected, all of the nodular or mixed type. In the first group were 13 clinically and bacteriologically positive cases who had received no treatment; in the second, 14 cases who had been receiving injections of chaulmoogra oil or its products for several months but were still clinically and microscopically positive; in the third, 16 who had become bacteriologically negative after varying lengths of time under similar treatment. These three groups are tabulated in Tables 1, 2, and 3.

The total number of cases is small, but the results, as far as they go, are definite and significant. In the group of untreated cases the percentage of positives was the average, that is, 60; in the second group the percentage is considerably higher, indicating the possibility of an increase in strength of complement-fixing substances during treatment, perhaps analogous to the so-called "provocative reaction" in syphilis. Finally, the sixteen cases of the third, or bacteriologically negative, group all allowed complete hæmolysis.

TABLE 1.—*Cases of untreated clinically and bacteriologically positive nodular and mixed cases of leprosy.*

Case No.	Age.	Duration of illness.		Wassermann reaction.
	Yrs.	*Yrs.*	*mos.*	
1	60		3	—
2	24	2	0	—
3	21	4	0	—
4	50	3	0	1+
5	20		10	1+
6	20	1	0	—
7	26		4	—
8	19		5	2+
9	35	12	0	4+
10	28	7	0	3+
11	33	1	0	3+
12	50	3	0	4+
13	28	2	0	3+

TABLE 2.—*Nodular and mixed cases of leprosy receiving treatment but bacteriologically positive.*

Case No.	Age.	Duration of illness.		Treatment period.	Wassermann reaction.
	Yrs.	*Yrs.*	*mos.*	*Mos.*	
1	32	4	0	3	—
2	63	3	0	4	2+
3	19	1	0	2.5	3+
4	20		4	3	(a)
5	23		2	2	4+
6	25	2	0	2	4+
7	18		3	2	3+
8	28		6	1	4+
9	22	2	0	1	1+
10	22	1	0	5	1+
11	50	20	0	5	3+
12	27	3	0	4	3+
13	20	2	0	2	4+
14	30		3	1	—

[a] Anticomplementary.

TABLE 3.—*Nodular and mixed cases of leprosy bacteriologically negative after continuous treatment.*

Case No.	Age.	Duration of illness.		Treatment period.	Wassermann reaction.
	Yrs.	*Yrs.*	*mos.*	*Mos.*	
1	43	(?)		9	—
2	32		2	2	—
3	45	1	0	(?)	—
4	24	4	0	(?)	—
5	38	10	0	4	—
6	22	(?)		16	—
7	27		3	10	—
8	47	4	0	8+	—
9	23	(?)		36	—
10	19	3	0	18	—
11	55	(?)		9+	—
12	78		2	19	—
13	32	(?)		2+	—
14	48	(?)		3+	—
15	19	(a)		15	—
16	20		3	15	—

[a] Two weeks?

These tests were performed on two occasions and each time samples of sera from the three groups were examined simultaneously, so that variations in technic were reduced to a minimum, and the chances of accidentally finding sixteen consecutive

negative cases when more than half of similar groups were positive are neglible. It seems evident that with continuous treatment, progressive clinical improvement, and disappearance of acid-fast organisms from accessible parts the substances fixing complement with lipoidal antigen are lost gradually.

TABLE 4.—*Percentage of positive Wassermann reaction in the three groups.*

Groups.	Cases.	Positive.	Positive.
			P. ct.
Untreated	13	8	61.5
Treated, bacteriologically positive	14	11	84.6
Bacteriologically negative	16	0	0

Much of the interest in the Wassermann reaction in leprosy has been stimulated by a desire to determine if positive reactions are due to an associated syphilitic infection. As a result numerous observations have been made on the effect of salvarsan on the positive reactions of lepers. Rocamora(8) observed no change in the reaction under prolonged treatment; a similar result was noted by Veillon and Lagane;(9) while Jeanselme and Vernes(5) state that a positive reaction continuing during treatment with salvarsan is useful in distinguishing between leprosy and syphilis.

Five cases of leprosy from the untreated group, three of whom had a strongly positive reaction and two a weakly positive, received injections of mercury for six weeks, and at the end of this period there was no change in the strength of the reaction in any of them.

The presence of a positive Wassermann reaction in leprosy in the majority of cases must be assumed to be a result of infection with *Bacillus lepræ;* the disappearance of positive Wassermann reaction appears to be a specific phenomenon associated with improvement in clinical signs and diminution in number of the acid-fast bacilli, the reaction not yielding to syphilitic therapy.

There are several considerations, however, which eliminate the Wassermann reaction from useful application as a measure of the effect of treatment in leprosy. The first of these is the small proportion of untreated cases which give a positive reaction, and the large proportion of weak fixations among those that do; for one of the most essential features of a successful test of this sort is that it be positive in practically 100 per cent

of cases and, preferably, strongly positive. Another disadvantage is the confusion which arises in excluding, in positive cases, possible associated infection with syphilis and, in many tropical countries, with yaws. It would be impracticable to resort to the therapeutic test to eliminate the possibility of these diseases in interpreting the reaction.

Interesting and important as the fact is, from an immunological standpoint, that sera of lepers become negative under treatment directed against the specific infection and do not yield to antisyphilitic drugs, it seemed useless to attempt an elaboration of the Wassermann reaction in the hope of utilizing it as a measure of the response of lepers to treatment. Consequently, investigation was made of the availability of other antigens for this purpose, namely, bacterial suspensions.

COMPLEMENT FIXATION WITH BACTERIAL ANTIGEN

Although extracts of various tissues, leprous and nonleprous, as antigens have in the hands of previous investigators given somewhat higher percentages of positive results than lipoidal antigens, as used in the Wassermann test, no investigation was made of these substances in view of the more-promising results reported from the use of bacterial suspensions, especially of *Bacillus tuberculosis* (human).

It is not surprising that complement fixation occurs with leprous serum in a certain proportion of cases in the presence of antigens of various acid-fast and even certain non-acid-fast organisms, in view of the experimentally demonstrated cross fixations with the sera of animals immune to a single species of the acid-fast group and antigen from various related bacteria. The subject of cross fixations with serum of animals immunized to acid-fast organisms has been investigated by Gengou,(3) Much and Leschke,(7) Claypole,(1) and others, and there has been a small number of investigations in which various bacterial antigens, especially of the acid-fast group, have been used in complement-fixation tests with leprous serum. These have been tabulated and discussed by Cooke who has added his own observations. The result of these studies has shown that bacillary suspensions are better antigens in complement-fixation tests with leprosy than lipoidal antigens or tissue extracts. In Cooke's series of experiments with sera from twenty cases of leprosy, in which antigens prepared from suspensions of eighteen different organisms, for the most part of the acid-fast group, were used, that of *Bacillus tuberculosis* (human) gave the

best results, yielding a positive test in 100 per cent, although five cases required 0.2 cubic centimeter of serum for fixation. One serum fixed complement with this antigen in 0.0005 cubic centimeter quantity. *Bacillus tuberculosis* of bovine and avian types and *B. smegmatis* were also excellent antigens, and several acid-fast organisms isolated from leprous lesions served almost equally well.

Before selecting *B. tuberculosis* (human) as an antigen for the following tests, antigens composed of four other organisms were compared with it. These organisms were two very distinct strains of streptothrices, *B. smegmatis*, and the mist bacillus. Antigens were prepared uniformly as follows:

The organisms were grown on glycerinated broth (in the case of *Bacillus tuberculosis* on glycerinated agar also), the culture suspended in broth, and precipitated by the addition of an equal volume of 95 per cent alcohol. The precipitate was removed by filtration or by centrifuging, and dried over sulphuric acid. It was weighed and ground in a mortar with sufficient sodium chloride so that, by the addition of distilled water, a 2 per cent isotonic suspension could be made. The 2 per cent suspension was shaken thoroughly with glass beads and used as stock antigen. In performing the test a 1 to 10 dilution was used. One cubic centimeter of this dilute antigen was not anticomplementary, and 0.5 cubic centimeter was used as the antigenic dose in each test.

Table 5 illustrates the relative value of these antigens with sera from five cases of nodular leprosy. Streptothrix II is a non-acid-fast organism, and Streptothrix I is acid-fast only in certain forms.

TABLE 5.—*Comparative complement fixation with leprous serum and bacterial suspensions.*

Case.	*Bacillus tuberculosis.*	Streptothrix I.	Streptothrix II.	*Bacillus smegmatis.*	Mist bacillus.
1	4—	4—	3—	3—	2+
2	4—	4—	2—	2—	1+
3	4—	4—	3—	3—	3+
4	4—	0	0	0	0
5	4—	0	0	0	0

The observation was made by Cooke that the value of a particular acid-fast organism as an antigen depends very largely on the physical character of its suspension in salt solution. The finer and more nearly even suspensions yielded the better results.

This appeared to be the case with the organisms in my experiments. The strain of *B. tuberculosis* was an old laboratory culture of low virulence and formed a good uniform milky suspension, while suspensions of *B. smegmatis* and mist bacillus were coarsely flocculent. The physical character of the antigen is undoubtedly one of the most important considerations in selecting one of several strains of *B. tuberculosis*. That used in the following tests was especially satisfactory in this respect.

Having selected *B. tuberculosis* (human) as the most suitable antigen, it alone was used in subsequent tests to compare the complement-binding strength of bacteriologically positive and bacteriologically negative cases of leprosy.

In the first group were sera from twenty-one cases of nodular and mixed leprosy and three of the pure, anæsthetic type. Treatment with ethyl esters of chaulmoogra oil had been begun only one or two weeks before the tests were made and as yet no noticeable clinical change could be observed, and each of the nodular and mixed cases was microscopically positive. The results of the tests are tabulated in Table 6.

TABLE 6.—*Clinically and bacteriologically positive cases of leprosy just beginning treatment.*

Case.	Sex.	Age.	Type.	Duration.		Complement fixation.
		Yrs.		*Yrs.*	*mos.*	
1	M	20	Nodular	2	0	4+
2	M	30	do		2	4+
3	M	15	do	4	0	4+
4	M	17	do		4	4+
5	M	20	do	2	0	4+
6	M	23	do		6	4+
7	M	24	do		7	4+
8	M	14	do	2	0	4+
9	M	37	do		6	4+
10	M	16	do	1	0	4+
11	M	23	do		6	4+
12	M	25	do		3	3+
13	M	50	do	3	0	4+
14	M	27	Mixed	6	0	3+
15	M	17	do	5	0	4+
16	M	59	do	1	0	3+
17	M	24	do	1	0	4+
18	M	30	Nodular		11	4+
19	M	33	do		6	4+
20	M	30	do	2	0	4+
21	M	26	Mixed	2	0	4+
22	M	40	Anæsthetic	2	0	2+
23	M	18	do	4	0	4+
24	F	50	do	10	0	3+

The second group was composed of sera from twenty cases of the nodular and the mixed types, which had become bacteriologically and clinically negative following treatment with chaulmoogra oil or its products after varying intervals. The results of the tests are recorded in Table 7.

TABLE 7.—*Clinically and bacteriologically negative cases of leprosy.*

Case.	Sex.	Age.	Type.	Duration of disease.		Duration of treatment.		Clinically and bacteriologically negative.		Complement fixation.
		Yrs.		*Yrs.*	*mos.*	*Yrs.*	*mos.*	*Yrs.*	*mos.*	
1	F	24	Undetermined	4	0	(?)		1	8	1+
2	F	45	Nodular	1	0	(?)		1	8	2+
3	M	25	do	1	0	1	7	1	4	2+
4	F	43	Mixed	(?)		2	3	1	2	—
5	M	32	Nodular	1	6	(?)		1	5	1+
6	M	47	do	4	0	1	5		9	4+
7	M	38	do	10	0	1	9		9	1+
8	M	27	do	2	0	(?)		(?)		4+
9	M	55	Mixed	2	0	(?)		1	7	1+
10	M	27	Nodular	4	0		11		5	3+
11	M	27	do		3	1	4		10	1+
12	M	78	do		2	2	3	2	0	2+
13	M	45	do	4	0	1	1		6	2+
14	M	48	do	1	0	(?)		1	8	—
15	M	26	do	11	0	5	11		2	4+
16	M	49	do	3	0	1	7	1	4	2+
17	M	20	do	4	0	1	10	1	3	1+
18	M	38	Mixed	2	0	1	6	1	2	1+
19	M	22	do	2	0	1	11		11	—
20	M	22	Nodular	(?)		2	8	1	4	1+

It is to be observed that 100 per cent positive fixations were obtained with twenty-four sera from cases just beginning treatment and that eighteen of the twenty-one cases of the nodular and the mixed types gave complete fixation and the three remaining almost complete. The three anæsthetic cases, while distinctly positive, were more variable, and they indicate, as was to be expected, a weaker reaction in this group. Comparison of these results with those in group 2, composed of bacteriologically negative nodular and mixed cases, shows a significant contrast. Of twenty cases only three gave complete fixation, two were negative, one strongly positive, and fourteen weakly positive. The conclusion is obvious that, with a gradual improvement in clinical evidences of the disease and a disappearance of demonstrable acid-fast organisms from the lesions, there is an accompanying diminution in complement-fixing substances in the serum, and the decrease may reach such an extent that they

become undemonstrable in a system designed for a maximum of 0.1 cubic centimenter of serum.

It is thus evident that the strain of *B. tuberculosis* used in these tests fulfills two important requisites for an antigen suitable for use in measuring immunologically the effect of treatment of leprosy with chaulmoogra oil and its products. In cases during early treatment it has given 100 per cent positive reactions and, for the most part, complete fixation. A very high percentage of positive results in untreated cases is a sine qua non if the method is to be of practical application. Secondly, with this antigen a measurable weakness in complement-fixing strength of sera in cases clinically and bacteriologically negative under treatment has been demonstrated, and the reaction may become negative within a reasonable time after disappearance of acid-fast bacilli from superficial lesions.

To be ideal, an antigen for this purpose should be absolutely specific for leprosy, but in this respect *B. tuberculosis* fails. For practical purposes, however, specificity of an antigen in a test to measure the decrease in complement-fixing strength is not so essential as in a similar test for diagnostic purposes, for here one starts with a positive fixation in cases already proven bacteriologically to have leprosy. In view of the close serological relation of complement-fixing substances in serum of animals immunized to various members of the acid-fast group, it is very doubtful if a specific antigen for leprosy not reacting with serum from human tuberculosis will ever be found. A complicating tuberculous infection cannot be excluded in cases of leprosy giving complement fixation with an antigen of *B. tuberculosis*. This, however, is not an insuperable objection to the test as proposed; for the majority of cases showing no clinical evidence of active tuberculosis will presumably, according to the above observations, show a diminution of complement-binding strength with improvement of leprous lesions, in which case active tuberculosis may be excluded. Those cases in which a complicating active tuberculosis is a factor in producing complement fixation, provided the tuberculous infection improves with the disappearance of leprous lesions, may show a weakening or a loss of complement fixation; for it has been observed that the strength of a positive reaction in tuberculosis appears to bear some relation to the severity of the disease, and reactions becoming gradually weaker until they became negative have been frequently noted(6) with clinical improvement and "cure." Under these circumstances the test will still be a valuable index

of the response of the patient. In case the reaction remains strongly positive and shows no tendency to weaken even after clinical "cure" of leprous foci, a complicating tuberculous infection should be suspected.

The antigen used in the above tests allows complete hæmolysis with syphilitic sera strongly positive with lipoidal antigen; consequently, a positive reaction offers no confusion with a coincident syphilitic infection. With many normal sera, and sera from various other diseases, the reaction has been uniformly negative. No test was made with tuberculous serum, though presumably the reaction would be positive.

DISCUSSION

A reliable serological method of measuring the response of leprous patients to treatment with chaulmoogra oil and its products would add invaluable data to the present evidences of clinical improvement and of the disappearance of acid-fast organisms from superficial lesions. An ideal method would be a specific complement-fixation test that would be positive in 100 per cent of untreated cases and that would become negative only after complete cure. It is futile at the present time to hope to obtain an antigen specific for leprosy; but the need is important enough to stimulate thorough investigation of antigens which may prove of practical value. The observations recorded above show that the Wassermann reaction is hardly worthy of further investigation as a possible test of broad application in leprosy, although of considerable immunological interest. *Bacillus tuberculosis* of the human type has given promise of being an antigen that may be of service, and thorough investigation of it is strongly recommended.

The sera of bacteriologically positive cases of leprosy contain complement-binding substances which react with suspensions of various acid-fast organisms, and especially well with *B. tuberculosis*, having yielded 100 per cent positive fixations in a series of twenty-four cases. The physical character of the bacillary suspension is of importance in selecting a suitable strain of *B. tuberculosis;* those forming the finest and most homogeneous suspensions will undoubtedly prove to be the best antigens, and it would be inadvisable to begin a series of studies unless a suitable strain fulfilling this requirement be used.

An extensive study of the subject has not been permitted, but there are certain very definite lines of investigation which are suggested by the results already obtained. It would seem important to titrate the sera of leprous cases before treatment is instituted to determine whether or not a relation exists between

the complement-binding strength and the duration or extent of lesions, and whether or not such relation proves to be directly proportional to the duration of treatment necessary to effect a clinical cure. By titrating the sera in this way the test performed at intervals during treatment may give, as does the Wassermann reaction in syphilis and yaws, a measure of the patient's response. Finally, we should seek to determine the meaning of a negative reaction induced by treatment with a view of more accurate individualization of treatment and detention of patients. At the present time we have no way of determining the state of infection in a leper who has become clinically and bacteriologically negative; that is, we cannot determine whether he is completely cured or how long he must continue under treatment to render him comparatively safe from recurrence. It has been shown in these relatively few observations that there is a wide variation immunologically among the group of clinically cured, bacteriologically negative cases, ranging from a strongly positive test to a negative complement-fixation test. Further observations may show that correspondingly important differences in the state of the infection also exist.

SUMMARY

1. The Wassermann reaction was found to be positive in 60 per cent of untreated nodular and mixed cases of leprosy and in 84 per cent of similar cases treated with chaulmoogra oil or its products for a few months but still bacteriologically positive.

2. In sixteen cases of nodular and mixed leprosy that had become clinically and bacteriologically negative under treatment with chaulmoogra oil the Wassermann reaction was uniformly negative.

3. One hundred per cent positive complement-fixation tests were obtained in twenty-four cases of nodular, mixed, and anæsthetic lepers, using an antigen composed of a suspension of *Bacillus tuberculosis* (human).

4. In twenty cases of nodular and mixed leprosy, clinically and bacteriologically negative after treatment with chaulmoogra oil or its products, two were negative, three gave complete fixation, one was strongly positive, and fourteen weakly positive, with a suspension of *B. tuberculosis* as antigen.

5. The complement-fixation test with bacterial antigen promises to be of service as a means of measuring the response of leprous patients to treatment.

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A POISONOUS CONSTITUENT IN CHOLERA STOOLS

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The histopathology of the intestine in cholera indicates that if poisonous materials are produced in the intestine, directly or indirectly as a result of the growth of vibrios, they are formed within the lumen of the bowel and not on an inflamed and denuded mucosa, for cholera vibrios are not primarily invaders of tissue. This is in contrast to the lesions found in infections with such toxin poducers as *Bacillus diphtheriæ* and *B. dysenteriæ* which regularly produce local necrosis, and which elaborate their poisonous products on and within inflammatory exudate. It is in contrast also to the effect of infection with *B. typhosus*, which brings about not only a local necrosis but also a bacteriæmia.

The vibrios of cholera do not produce an exotoxin and they do not cause septicæmia, two sources of profound intoxication which may be eliminated; and search for the poisonous agent of the disease has led most investigators to the conclusion that it is the endotoxin which has been demonstrated to exist in the substance of these organisms. Pfeiffer was unable to demonstrate a soluble toxin in young broth cultures, but showed that young killed cultures were very toxic. Wasserman confirmed this finding and showed that the toxin exists as a constituent of the bacterial cell, becoming soluble only by disintegration of the cellular body. Strong(1) also demonstrated an intracellular toxin, and found that much of it was destroyed by heat at 60° C. and that it appeared to be completely destroyed by boiling. He suggests that the stage of most violent symptoms in human cholera may coincide with a period during which rapid dying off of spirilla and, possibly, the setting free of the largest amount of toxic substance occur.

The sudden and often violent onset of the disease with early collapse, fall in blood pressure, low body temperature, and loss of fluid through the intestine are sufficiently unique to suggest the possibility of a fundamental element in the pathogenesis of

cholera which is lacking in other infectious diseases. Indeed, these symptoms have a greater similarity to those of high intestinal obstruction than to another enteric infection. Not only may the above symptoms of profound intoxication be in evidence in acute ileus but there is also a great loss of fluid through the intestine; much of it may be vomited, and at autopsy, especially in paralysis of the intestine, it may fill and distend the small bowel, particularly the upper portions.

Whipple(2) has been able, by alcoholic precipitation, to isolate from the fluid in experimentally closed duodenal loops a toxic substance which, injected intravenously into dogs in small amount, produces profound collapse and other symptoms of duodenal obstruction.

It has been possible, by precipitating with alcohol filtered watery stools and intestinal fluid from cases of cholera, to demonstrate the presence of a similar poisonous substance producing, when injected intravenously or intraperitoneally into dogs, a train of symptoms and pathological changes identical with those caused experimentally by poison from closed duodenal loops. It was to be expected, with the excretion of quantities of fluid in cholera, that whatever dissolved poisonous material might exist would be considerably diluted, and this is the case with the toxic material which has been demonstrated. The degree of toxicity was first estimated by intravenous injection of intestinal fluid removed at autopsy from the ileum three hours post mortem.

EXPERIMENT 1

November 29. Four hundred cubic centimeters of watery mucus-containing fluid were removed from the ileum three hours after death from a case of typical cholera, bacteriologically positive, dead two days after onset. Within one hour fluid was placed in ice box at 5° C.

November 30, 3 p. m. Ten hours later 150 cubic centimeters were placed in a flask in boiling water for a half hour. Precipitate removed by centrifugalization. Supernatant fluid acidified weakly to litmus with acetic acid, boiled, and the light flocculent precipitate removed by centrifuging.

At 3 p. m. 100 cubic centimeters of the clear brownish fluid were injected intravenously, under morphia and ether anæsthesia, into an adult dog weighing 8 kilograms. There was a gradual fall in blood pressure and an increased pulse rate, but no vomiting or diarrhœa. The animal died during the night,

apparently from morphia intoxication as it did not recover completely from anæsthesia.

It was evident from this experiment that in 100 cubic centimeters of fluid thus treated only a small quantity of toxic material was present. In the remaining experiments a light flocculent precipitate was removed from the intestinal fluid by the addition of alcohol, and this fraction redissolved and injected into dogs was found to be toxic.

EXPERIMENT 2

Two hundred cubic centimeters of fluid, prepared from the sample used in the above experiment, exactly in the same way, was strongly acidified with 2 cubic centimeters of glacial acetic, and an equal volume of 95 per cent alcohol added. An abundant flocculent precipitate resulted which was separated by centrifuging, washed twice with 95 per cent alcohol, once with absolute alcohol, and once with ether, pressed between filter paper, and dried; weight 0.3 gram. Most of this material dissolved on warming in 20 cubic centimeters of water made alkaline with sodium carbonate. A small undissolved residue was centrifuged off. The supernatant fluid was injected intravenously into a dog weighing 7 kilograms, under light ether anæsthesia, at 10.30 a. m. At 11 a. m. the animal had recovered from the anæsthesia. He was vomiting bile-stained material; respiration was deep and labored, pulse weak. Salivation was noticeable and a little later tenesmus with the passage per rectum of a small amount of mucus-containing fluid. At 12 noon his condition was improved, and recovery followed.

The substance recovered by alcoholic precipitation evidently contained toxic material, but this fluid removed from the intestine post mortem contained much more proteid than the watery discharges from patients early in the disease, and the alcoholic precipitation recovered from the latter proved to be more toxic.

EXPERIMENT 3

From 500 cubic centimeters of clear amber colored stool with flakes of mucus on the surface, from a typical case of cholera one day after onset, 0.355 gram of dried alcoholic precipitate was recovered. The original fluid stool was strongly alkaline. It was acidified weakly to litmus with acetic acid, and boiled. A light flocculent precipitate was removed by centrifuging. To the remaining supernatant fluid (500 cubic centimeters) two volumes of 95 per cent alcohol were added.

The precipitate removed by centrifuging was washed twice with 95 per cent alcohol, once with absolute alcohol, once with ether, and then dried. Two hundred milligrams of the dried precipitate were dissolved in 10 cubic centimeters of water made alkaline to litmus with sodium carbonate. A small fraction remaining undissolved was removed by centrifuging. This solution was injected intravenously into an adult dog weighing 4.2 kilograms, under light ether anæsthesia.

Before injection, pulse was 110; respiration, 20; rectal temperature, 39° C.

11 a. m. Solution injected slowly. Began to heave during injection. Shortly afterward pulse was weak and mucous membranes pale. Came out of anæsthesia slowly. Bowel movement consisted of hard fæces. Got up and moved position. Listless and sick.

12.30 p. m. In complete collapse. Did not resist changes in position. Muscles flaccid. Had voluminous fluid stool containing flakes of mucus. Profuse salivation. Pulse 90, respiration 24, rectal temperature, 37.5° C. Had rigors with stiff legs and neck.

1.00 p. m. Dead. Had more fluid bowel discharges. Autopsy showed general splanchnic congestion, with intense, brick-red congestion of duodenal mucosa, the intensity gradually fading off about 2 feet below the pylorus. Lumen of small intestine filled with bile-stained fluid and mucus. Colon pale and filled with fluid. Liver congested. Gall bladder injected and œdematous. Heart's blood clots very slowly.

In another experiment 0.3 gram of dried precipitate from a different case injected into a dog weighing 5.6 kilograms was fatal in one hour, with symptoms and pathological changes the same as those described in experiment 3. In a third, 0.4 gram was injected into a dog weighing 6.6 kilograms followed by similar symptoms but resulting in recovery. Sublethal doses of several other preparations of dried alcohol precipitate were used; the estimated fatal dose varied in different ones, but was about 0.1 gram per kilogram.

In the following two experiments unboiled fluid was used, and this seemed to be more toxic than fluids subjected to greater heat.

EXPERIMENT 4

Fifteen hundred cubic centimeters of fresh fluid stools from cholera patients, within two or three hours after passage, were heated in flasks, immersed in boiling water, for fifteen minutes.

The flasks were then placed in the ice box at 10° C. for several weeks until the material in suspension had sedimented, leaving a clear supernatant fluid. This was passed through a Mandler filter. The filtrate was water clear and amber colored. Five hundred cubic centimeters were made acid by the addition of 2 cubic centimeters of glacial acetic and two volumes of 95 per cent alcohol were added. A light flocculent precipitate separated out, estimated at about 0.2 gram. This was removed by sedimentation and centrifuging, and washed once with 95 per cent alcohol. The alcohol was decanted and the precipitate completely dissolved at room temperature in 20 cubic centimeters of water made slightly alkaline with sodium carbonate. This solution injected intravenously into a dog weighing 6 kilograms resulted in vomiting, watery diarrhœa, collapse, and death within one hour. Autopsy showed splanchnic congestion and intense reddening of duodenal mucosa.

The precipitate from an additional 500 cubic centimeters treated in the same way was injected intraperitoneally at 10 a. m. into a dog weighing 5.5 kilograms. There followed almost immediate collapse, fall in blood pressure, labored respiration, urination, and tenesmus. At 11.30 a. m. collapse continued. Passing watery discharges from bowel. Pulse could not be felt at 12 noon. Copious fluid fæcal discharges. Vomited blood-stained fluid. Convulsions. 12.30 p. m., dead. At autopsy an intense congestion of the intestinal mucosa was found, although the peritoneal surfaces were pale and smooth. Large, irregular, brick-red splotches of congestion were distributed throughout the mucosa of the small bowel. Mucosa of colon congested.

Since the fluid stools from cholera patients contain practically no proteid precipitable by heat and acetic acid, the above method of preparing the alcohol precipitate from water-clear fluid which has passed through a diatomaceous filter is much the best. Even an initial heating to sterilize the fluid is not absolutely necessary; initial heating may destroy some of its toxicity but was uniformly done in these experiments as a precautionary measure. It has been found more difficult to dissolve the dried precipitate than that washed once with alcohol, and the washed preparations appear to be more toxic.

No attempt has been made to purify the poison contained in the fæcal precipitate, and it is undoubtedly brought out of solution along with other substances. Precipitation from an acid solution is much easier than with the natural alkaline reaction. Four volumes of alcohol or more are necessary with

fluid which is alkaline, while two volumes cause complete flocculation in a very short time when it is strongly acidified with acetic acid.

DISCUSSION

Even in the crude form obtained by this method the precipitated substance is much more toxic than are most preparations of proteoses and peptones which ordinarily are lethal for dogs only in doses of 0.5 to 1 gram per kilogram. The blood-pressure reaction is also different, in that there is a more-gradual and prolonged fall. In other respects the intoxication is similar to that produced by the products of proteid digestion; namely, salivation, vomiting, diarrhœa, and incoagulability of the blood.

Even though this experimental collapse with its attendant symptoms is produced in a very artificial manner it has, nevertheless, a certain resemblance to the manifestations of the more-violent cases of cholera in man, as well as to those of high intestinal obstruction. There is nothing specific about the symptoms produced experimentally; they are common no doubt as a reaction to a number of products of proteid disintegration. It is, however, suggestive that a poisonous material giving such a reaction is present in cholera stools.

The conditions under which poisonous products of proteids are found are those in which body proteids or bacterial proteids may be rapidly broken down. Such is the situation in high intestinal obstruction and in experimentally closed duodenal loops. Bacteria proliferate in enormous numbers in a location where normally but few occur, and in this situation are the active proteolytic ferments of the body from pancreas and intestinal mucosa. The conditions are certainly favorable for a rapid splitting up of both body and bacterial proteids.

It seems not altogether unwarranted to see in cholera an analogous condition. In this disease there is certainly a prolific growth of vibrios in the small intestine in its upper portions as well as in its lower. They grow readily in alkaline intestinal juice, where normally there are practically no bacteria. In cultures, and perhaps in the intestine, they reach a maximum growth in from twelve to twenty hours, after which rapid death takes place. It would seem entirely possible that at this stage their bodies are disintegrated by the action of proteolytic enzymes with the liberation of toxic split products.

The toxic material isolated by alcoholic precipitation may be formed in this way. Although considerably diluted by intes-

tinal fluid, it can nevertheless be demonstrated in sufficient quantity to be a possible factor in the disease. Post mortem more than a liter of fluid may be present in the small intestine, which would contain at least 1 gram of alcoholic precipitate, or more than enough to kill a dog, weighing 10 kilograms, when injected intravenously.

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ALEXANDER SCHADENBERG, HIS LIFE AND WORK IN THE PHILIPPINES

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ONE PLATE

Botanists and zoölogists in the Philippines know of a number of plants and animals that bear specific names derived from the family name of their discoverer, Schadenberg, and the ethnographer not unfrequently comes across this appellation in his literature on Luzon, Mindanao, and Mindoro; yet, of the man who bore that name practically nothing is known to the present generation of residents in the Islands. It may therefore be of interest to present here a short biographical sketch of this precursor of our present-day research workers, a man who in his day sealed his devotion to the scientific exploration of the Philippines with his life.

Alexander Schadenberg was born in Breslau, Germany, on June 27, 1851, the son of a court dignitary.[1] After graduating from the gymnasium of that city he was apprenticed for some time to a local pharmacist and later, with the practical knowledge thus acquired, entered Breslau University for the study mainly of chemistry, pharmacy, and botany. His great talent and predilection for all branches of the natural sciences soon made him a favorite with his teachers, among whom were such eminent men as Goeppert, the botanist. His record in chemistry under Doctor Loewig was so excellent that at the early age of 23 years, young Schadenberg, having achieved the degree of Doctor of Philosophy, was appointed assistant director of the Potassic Salt Works at Stassfurt, where he worked until 1876 to the satisfaction of his employers. An inborn longing, however, for the exploration of unknown countries overseas did not allow him to remain long at home. A position as chemist being

[1] I am following notes kindly furnished me by a member of Schadenberg's family now living in Europe, but I see that Blumentritt in an obituary notice in Int. Arch. f. Ethn. Leyden 5 (1896) 151 gives the date of birth as May 27, 1852.

offered him by the wholesale drug firm of Pablo Sartorius in Manila, he accepted the post and bade good-bye to his native land.[2]

He remained with this firm for three years and indicated his interest in the exploration of the Islands by a number of excursions into the interior, visiting among others the Negritos of Bataan, Zambales, and Pampanga. A severe attack of a pernicious fever compelled him to return to Breslau in 1879, not, however, without having previously worked out with a Manila friend, Otto Koch, a plan for the exploration of southern Mindanao, especially the country around Mount Apo on Davao Gulf. For a while the execution of this plan seemed endangered by Schadenberg's engagement, in the spring of 1881, to a young countrywoman of his. The interest, however, which all parties concerned took in the projected expedition, from which valuable results were expected for science, was sufficient to induce the young couple to agree to a temporary separation. Thus, in August, 1881, supplied with all necessary instruments and with articles of exchange for dealing with the natives, Schadenberg set out again for the Philippines, accompanied by his friend Koch. In Mindanao the Spanish authorities of those days, while ready to lend every possible help, showed themselves sincerely concerned about the safety of the travelers intent on losing themselves in the wilds of the country behind Davao, a region which in parts remains unexplored even to-day. By December, however, the two friends had established themselves beyond the pale of civilization, in the Bagobo village Sibulan, south of Mount Apo, where, in exchange for some coils of brass wire, they had purchased the handsome bamboo cottage of one of the headmen. During their stay here of about six months they made the tribe among which they lived, and which was notorious for the practice of human sacrifice, the object of a close ethnographic study, drawing up also a vocabulary of the language.[3] They assembled an extensive collection, both of ethnographic objects and of specimens of the local flora and fauna,

[2] An uncle of Pablo Sartorius, F. Steck, was the first to devote himself in Manila to the distillation of ilang-ilang oil [Pharm. Zentralh. 9 (1868) 46]; the Sartorius brand of this essence, then the object of a flourishing industry in Manila, came to acquire a worldwide fame.

[3] This vocabulary contains among other things the native names of nine plants; also of forty-two birds, the skins of which Schadenberg brought home.

securing of butterflies alone some 20,000 specimens which they collected with the help of a young Bagobo specially trained by them for this work. From Sibulan as a base, they undertook a number of exploring trips into the surrounding country; the especially notable expeditions were two successful ascensions of Mount Apo [4] on February 20 and March 16, 1882, and a trip to the mountain Párag, north of the volcano, which led to the discovery of a new species of *Rafflesia*, a giant parasite, the open flower of which measured 80 centimeters in diameter; this species was afterwards called *Rafflesia schadenbergiana* Goeppert.[5]

The expedition to Mindanao ended with an exploration of the burial caves on the small island of Samal, which was greatly facilitated by the authorities at the Spanish Naval Station at Davao, who placed the gunboat *Nuestra Señora del Buen Viaje* at the disposal of the travelers. The exploration of this island was not less successful than had been that of the hinterland of Davao, and Schadenberg enriched his collections with a number of skulls, prehistoric dugout coffins, and many specimens of equally old Chinese pottery.

The end of July of the same year saw Schadenberg and his treasures back in Breslau. It was his intention, after having established his family, to dedicate himself primarily to the working over of his collections. Unwilling to bind himself to any institution or museum, he secured the financial support for such work by purchasing the Hofapotheke [6] in Glogau, Silesia, where he spent the following three years (1883 to 1885). It was mainly during this time that he entered into friendly relations with several European museums and was made corresponding member of various anthropological and ethnographical societies in Berlin, Vienna, Dresden, Leyden, and Paris. Official recognition of his scientific zeal was given by the bestowal of some orders and crosses. His publications on the results of his trips he supplemented with a number of lectures;

[4] On Mount Apo the explorers, at each of their ascents, left their cards on the very apex in a bottle, placed neck down in the ground, one of which was found some nineteen years later by Phelps Whitmarsh, as related in his "Ascent of Mount Apo," The Outlook, March 23, 1901.

[5] Two rather young buds of this plant growing close together on a stem, when roughly weighed in the field, were balanced by a heavy double-barreled rifle and six solid bullets.

[6] A drug store, given official distinction by such title.

at the Anthropological Congress, held under the presidency of Virchow in Breslau in 1884, he spoke on the artificial deformation observed in ancient skulls found by him on Samal.

All this but served to maintain and increase his desire for further exploration in the Philippines. When, therefore, upon the death of one of the partners of Pablo Sartorius in Manila, he was offered the place thus vacated, he accepted it, the more readily as his destination this time was to be not Manila whose climate had before proved disastrous to his health, but the more salubrious Vigan, the capital of Ilocos Sur, where he was to manage a branch of the Manila office, and from where he hoped to carry out certain plans for the exploration of northern Luzon.[7] He arrived with his family in Vigan in November, 1885, and the next year he made his first expedition into the Cordillera Central where he visited the people of Balbalásan, Pagpagó, Gináang, Lubuagan, and other mountain settlements, situated in what to-day is Kalinga Subprovince. In the following year (1887) he went to Bontok, Talubin, Banawe, Sapao, Asin, Lahutan, and Suyuk. In the absence of details of his itineraries it is impossible to give the exact route taken by him in this and in other expeditions. In the present instance, however, we have his letter from Vigan, dated October 10, 1887, to the Anthropological Society in Berlin, in which he says:

> I have so far visited in detail the inhabitants of the provinces of Abra,[8] Bontok, Lepanto, La Union, and parts of Nueva Vizcaya and Isabela. The much-discussed question of [classifying] the Igorots I dare not approach yet; this problem they solve in Europe with more ease than we here on the spot. * * *

From the photographs taken by Schadenberg among the mountain tribes of northern Luzon, a collection of which is now in the possession of Prof. H. Otley Beyer, it becomes evident that Schadenberg at some time passed also through Benguet Subprovince, traveling with his wife through the valley of Agno River. But the most courageous advance made by him into the interior of the mountain region was undoubtedly his expedition into the country of the head-hunting Apayaos, undertaken in

[7] Another source gives him as owner of the drug store in Vigan directly purchased by him from the Manila firm with the preconceived object of carrying out from this base his plans for the exploration of northern Luzon. It may be pointed out here that Schadenberg was in the habit of financing all his expeditions from his personal means, acquired chiefly as the result of previous professional labors.

[8] Abra was at that time reckoned to extend farther east than at present.—Translator's note.

1889, just at a time when the relations between these and the Christian lowlanders were at their worst. Though habitually averse to any display of force, he had to consent, in this instance, to his Ilokano carriers arming themselves; still, after reaching the settlements around the present township of Bayag, in northern Apayao, it was not hostility on the part of the Apayaos, but much fever among his carriers that compelled him to desist from his plan to reach Malaueg in Cagayan, and return by way of the Saltan and Abra. He had, however, the satisfaction of being able to induce five of his newly won Apayao friends to come down with him to Dingras, in Ilocos Norte, where their presence caused considerable sensation. Mounted messengers having carried the news to the provincial governor, Don Manuel Sastron, in Laoag, this functionary availed himself of the opportunity to improve the existing trade relations with the mountaineers. These had consisted in a peculiar system of barter, according to which the Apayaos deposited their chief product, tobacco, at certain neutral spots and then retired, after having given advice to the "cristianos" by signs and shouts. The latter came up and deposited at the side of the tobacco bundles the estimated equivalent in native fabrics, wire, iron, and beads, and then retired in their turn, whereupon the Apayaos came forward again to inspect the articles thus offered in exchange. If these were found suitable, they took them up and left the tobacco in their place; if found insufficient, they took away part of the tobacco and left only the quantity considered a fair return for the Ilokano goods, waiting thereafter in retirement to see if the Ilokanos signified their agreement. This crude type of barter at a safe distance Sastron sought to improve by giving to Schadenberg's companions official documents authorizing them to trade freely and directly with the Christian towns and promising every support and protection.

In 1890 Schadenberg paid a short visit to his native country, returning with his family to the Philippines in the spring of 1891. The old firm of Pablo Sartorius, which had been changed to that of Boie and Siegert, now became Boie and Schadenberg. The latter was henceforth obliged to reside in Manila and, on resuming his trips into the provinces whenever he could find the time, he was warned against the danger to his health arising from his known propensity to fevers, especially those of the malarial type. Notwithstanding this, he soon developed an irresistible desire to find out more than was known at that time about the interior of Mindoro Island, in easy reach from Manila;

an ascent of Mount Halcon (2,587 meters) and a study of the Mangyans [9] were uppermost in his mind. He visited the island for the first time in 1894, and a second time in the following year, bringing back valuable results from each trip. In spite of the germs of malaria lurking in his veins, he had planned a third trip to Mindoro which was to take him to the top of Mount Halcon in 1896, when death overtook him on January 26 of that year, at the early age of forty-four years. At the time he was staying, for the sake of recuperation, at the house of his friend, the Spanish governor Cadrana in Capiz, Panay.

Schadenberg's work of exploration in the Philippines has borne fruit in a number of papers of which he was the author, as well as in a not inconsiderable literature on his discoveries by others. A bibliographical list of these works is appended and it has been made as nearly complete as possible. It finds its natural supplement in his collections, which are found in the museums of Dresden, Vienna, Berlin, and Leyden. How fruitful Schadenberg's work in the field became for the scientist confined to his study at home may be shown by an example. Considering that Schadenberg's specialization lay in the field of natural sciences, it cannot well be expected that linguistics played more than a secondary rôle with him. Yet the Negrito vocabularies collected by him in the Bataan–Zambales region were considered worth being twice made the object of very painstaking examination by such an eminent authority as the late H. Kern, of Leyden,[10] whose findings are as yet the last word that has been said regarding such interesting questions as the relation of Negrito speech to the Philippine languages, and the presence in the former of possibly unrelated elements suggesting remnants of an earlier and now extinct language peculiar to this race of dwarfs. This is also true in regard to Schadenberg's collection of Mangyan writings on Mindoro, worked over by Dr. W. Foy in Dresden.[11] Among the traits of character that so peculiarly fitted Schadenberg for his work as an explorer we distinguish, besides tenacity of purpose and fearlessness, that sterling and directly convincing integrity which alone rendered it possible for him to carry on his work in the midst of a society of Filipinos, Spaniards of all classes, and crude mountaineers with their widely divergent ideals. He was welcomed and given much aid in many a provincial convento or parsonage,

[9] For the form Mangyan see Philip. Journ. Sci. 7 (1912) 135, 157.
[10] See appended bibliography under C. 1882 and 1893.
[11] See appended bibliography under B. 1895.

and he was a personal friend of Doctor Rizal in whom he took great interest and who made him the recipient of all his writings. Above all, however, he was possessed of an almost passionate interest and zeal for scientific exploration which, when necessary, bade him sacrifice all that is generally held dear by men and which make him worthy of emulation. Honor be to his memory!

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ILLUSTRATION

PLATE 1. Alexander Schadenberg, from a photograph.

PLATE 1. ALEXANDER SCHADENBERG.

CERTAIN DEVELOPMENTAL STAGES OF ASCARIS LUMBRICOIDES OVA IN THE LIVER TISSUE

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ONE PLATE

The eggs studied in the present paper were observed by one of the authors of this article while examining a histological section of the liver of a child, 3 years old, who died of tuberculous meningitis. These ova are of particular interest, not only because of their peculiar location in the host body, but also because they seem to be at variance with the common belief that ascaris eggs are capable of segmenting only after they have passed out of the body of the host.

History of the case.—The patient was a poorly nourished, emaciated, highly irritable, female Filipino child, 3 years old. She was living with her grandmother who had pulmonary tuberculosis. The patient was admitted into the hospital with symptoms of meningitis after having been sick for nine days outside. When she was one and a half years old she had fever and chill occasionally for four months, oftentimes associated with abdominal pains, tympanism, and vomiting. Nine months later the child passed several ascarides, and since then repeatedly passed the same kind of worm, either per mouth or per rectum. About one week previous to admission she vomited one large ascaris. There was no history of colic or jaundice, nor was there any mention of passage of worms during her stay in the hospital. In this institution a lumbar puncture was performed and about 10 cubic centimeters of clear fluid with some white flocculent precipitate were obtained under low pressure. The spinal fluid was negative for tubercle bacilli, and the number of cells was 5 per cubic millimeter. The proportion of lymphocytes was 80 per cent, of neutrophiles 20 per cent.

The child died nine days after admission, after having presented a dramatic aspect of generalized convulsions, with twitching of the muscles of the face, distended and tympanitic abdo-

men, and marked hyperpyrexia, the temperature often reaching 40.5° C.

Clinical diagnosis.—Tuberculosis, generalized; meningitis, tuberculous; peritonitis, tuberculous.

Autopsy.—Autopsy was performed eighteen hours after death. Body was that of a well-developed but poorly nourished female Filipino child, 3 years old, 88 centimeters in length, and 9.1 kilograms in weight. The eyeballs were moderately protruding, the pupils equal and not dilated. The lymph glands of the neck and axillary regions were slighty palpable. The abdominal cavity contained about 50 cubic centimeters of clear straw-colored fluid. The serosa of the intestine in the last portion of the ileum showed a few minute tuberculous nodules. The mesenteric lymph nodes were considerably enlarged, and many of them contained caseous material. The lungs were moderately congested; on section they showed a few minute tubercles at the level of the apices. The peribronchial glands were slightly enlarged, and some of them contained calcareous material. The spleen was normal except for the presence of a few very minute tubercles visible on the surface of the organ.

The liver showed evidence of marked fatty degeneration. Ascarides were not found either in the gall bladder or in the bile ducts. The stomach was apparently normal. The mucosa of the last portion of the ileum showed irregular tuberculous ulcers. These were found in places just opposite the tuberculous nodules found in the serosa. No adult ascaris was found in any part of the alimentary tract. On opening the skull, the cerebrospinal fluid was found increased in amount and somewhat turbid in appearance. The ventricles of the brain were dilated and filled with turbid fluid. Laterally on the brain surface, and at the level of the base, especially along the course of the large blood vessels, a few conglomerations of minute grayish tuberculous nodules were encountered. The right hemisphere of the cerebellum was almost completely involved by a yellowish opaque tubercular mass; this was firm in consistency and on section it showed a whitish central portion apparently composed of fibrous tissue. The periphery was more yellowish in color. The cut surface of this mass showed also some minute gray nodules scattered through the substance of the tumor.

Anatomical diagnosis.—Tuberculoma of the cerebellum; tuberculous meningitis; tuberculous enteritis, ulcerative; fatty degeneration of the liver.

The histological diagnosis of the tissues confirmed the above anatomical findings.

Location and identification of the eggs.—The eggs were accidentally discovered in one of the blocks from the liver tissue; a rounded, fairly well circumscribed mass was found around a portal area, about 2 to 3 millimeters in diameter. The bile duct of this portal area was greatly dilated; the basement membrane was moderately infiltrated with rounded cells and polymorphonuclear leucocytes, and the connective tissue around it was considerably increased in amount showing at the same time evidence of endothelial cells, rounded cells, and polymorphonuclear infiltration. There were also apparently some accessory bile ducts and some blood vessels. This portal area seemed to be fused with the mass previously mentioned. The mass contained numerous eggs in various stages of segmentation. In shape, size, structure, and general appearance, the eggs in question were unmistakably those of *Ascaris lumbricoides.* They were elliptical, round or oval bodies with a thick transparent cell wall. The extra albuminous coat was invariably absent. The vitelline membrane was fairly visible in many of the ova. They measured on the average from 45 to 65 μ in length and from 45 to 50 μ in width.

The ovarian cells were in various stages of segmentation. One-cell, two-cell, four-cell, and eight-cell stages were found. In some the yolk granules were fairly visible around the segmenting ovarian cells. These eggs lay in a matrix composed of connective tissue showing evidences of necrosis, especially around the eggs. In the meshes of this connective tissue there were also numerous endothelial cells which in certain places were fused together, forming beautiful giant cells. Some of these collected around the ova trying to engulf them. Centrally, between the eggs, there were also in some places large deposits of fibrin and very few polymorphonuclear leucocytes. The peripheral portion of the mass was almost entirely composed of fairly well preserved connective-tissue cells, numerous polymorphonuclear leucocytes and endothelial cells, some eosinophiles and round cells, and a few fibroblasts.

The liver cells in the rest of the liver tissue showed evidence of marked fatty degeneration. The connective tissue of the other portal areas was also increased in amount, and infiltrated with round and polymorphonuclear cells.

The above findings, coupled with the advanced inflammatory reaction of the tissue involved, afford us no scientific basis upon which we might determine the exact location of the eggs in spite of the fact that serial sections were made of the affected area. It is probable that they were confined originally within the portal area and that the inflammatory process and necrosis extended afterwards into the parenchyma of the liver tissue. This explanation is more or less in harmony with the observations of several authors who found ascarides very frequently in the intrahepatic bile ducts; and, although in the present case the worms were not found in the bile ducts on the autopsy table, the cellular infiltration and fixed tissue reaction of the portal areas as found microscopically are factors that can be taken into consideration, and they perhaps explain within certain limits the result of the migration of the worms into the interlobular bile ducts.

On the other hand, the extensive productive inflammation and the necrosis around the ova can be interpreted as due not only to a simple mechanical factor (as any other foreign body), but probably also to the presence of some substance secreted by the worms. In this connection we might mention the names of Shimamura and Fujii who have isolated from the horse ascaris a toxic substance which consisted of a mixture of albuminoses and peptone that gives rise to toxic symptoms when injected into the horse.

DISCUSSION

The peculiar location of these eggs naturally raises the question as to how they happen to be deposited there. The absence of ascaris in any part of the alimentary tract and accessory organs at autopsy precludes the possibility of any post-mortem oviposition in that locality by migrating ascarides. The advanced tissue reaction of the part involved and the advanced stages of segmentation that the eggs have undergone, taking into consideration the relatively short time that elapsed between death and autopsy, support this view. Because of these facts we are inclined to believe that they must have been deposited ante mortem, previous to admission, in as much as there was no history of the passage of ascaris during the patient's stay in the hospital and no ascaris was encountered during autopsy.

Migration of ascarides into the common bile ducts and thence into the gall bladder or into the intrahepatic bile ducts has been frequently reported, and verified by frequent findings at operation or autopsy.

Such migration of ascarides into the different organs is attributed to the altered chemico-physical condition of the normal habitat of the parasite brought about by abnormal conditions of the host body such as high temperature in febrile affections. In the present case, it is not at all unreasonable to suppose that the high temperature concomitant with meningitis had rendered the small intestine unfavorable for the parasites and caused them to become erratic. In intestinal ascariasis, as suggested by Crowell,[1] one or more of the ascarides in the small intestine may pass through the ampulla of Vater and cause occlusion, followed by icterus, and symptoms of colic. It is true that in the present case the clinical history records no symptoms that suggest this condition, but it must be borne in mind that the marked clinical signs of meningitis might have masked other symptoms. It is possible that the worms, after ovipositing, might have traveled back to the duodenum without leaving behind any trace of their invasion exept the presence of their eggs. In this connection we might mention here Vierodt's observation, that mature female ascarides can penetrate without doubt into the liver and there deposit eggs which appear exceptionally to undergo segmentation. On the other hand, the eggs possibly laid in the common bile ducts, or in the gall bladder, might have been carried by the back flow of bile caused by some temporary occlusion into the intrahepatic bile ducts, thereby causing necrosis of the portal area and the surrounding liver tissue.

It is a matter of common knowledge among parasitologists that ascaris eggs are laid normally in the small intestine before segmentation, and are passed outside with the fæces where cleavage of the ovarian cells takes place. The occurrence of segmenting ova in such an organ as the liver, discussed in this paper, is contrary to this common belief. It also shows that a very small amount of oxygen is required to initiate segmentation. Among the eggs we studied in this paper, none was found to have passed the 8-cell stage. This seems to be in conformity with Wharton's observation[2] that "At 37° C. development will begin, but all of the eggs die either in the 4- or the 8-cell stage," if we disregard entirely the time element, which in our case is not determined. Whether or not the eggs in question could have developed in time into motile embryo stages

[1] Journ. Am. Med. Sci. **159** (1920) 380–398.

[2] Philip. Journ. Sci. § B **10** (1915) 21.

capable of auto-infecting the host is entirely a matter of conjecture; but the possibility certainly suggests itself that they could develop, as do those of *Tænia solium* and *Hymenolepis nana*.

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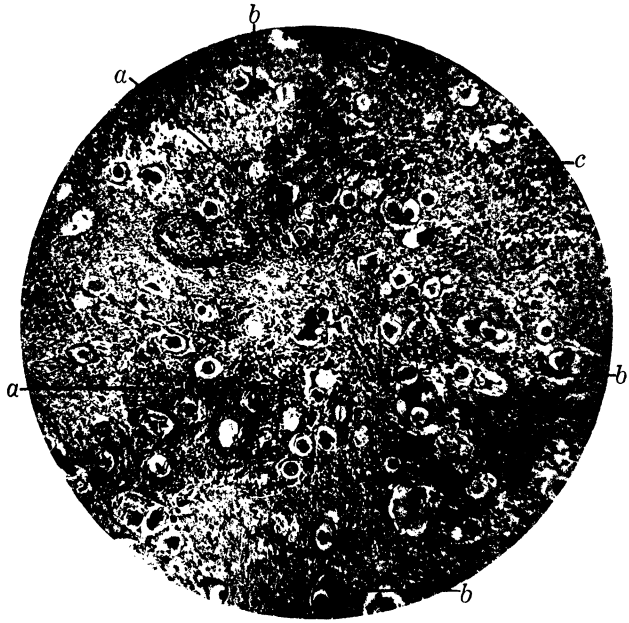
ILLUSTRATION

PLATE 1. ASCARIS IN LIVER TISSUE

FIG. 1. Photomicrograph of the area of liver involved as seen with the low power. It shows numerous eggs at various stages of segmentation; *a*, shows an amount of fibrin collected around the ova; *b*, shows beautiful giant cells trying to engulf eggs; *c*, shows the leucocytic infiltration at the periphery of the mass.

2. The same area as is shown in fig. 1, more highly magnified. The structure of the ova is here well demonstrated. The vitelline membrane is fairly visible as are also the segmenting ovarian cells. The ova are surrounded by necrotic tissue showing endothelial and some polymorphonuclear infiltration.



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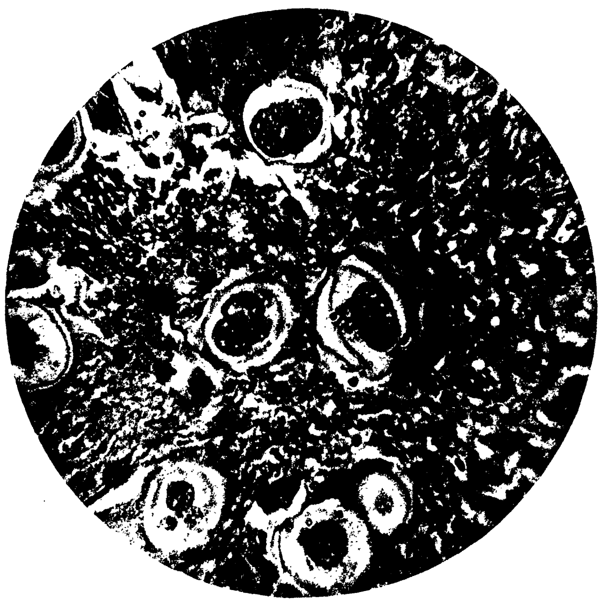

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PLATE 1. ASCARIS EGGS IN LIVER TISSUE.

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THE PHILIPPINE JOURNAL OF SCIENCE

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UNDESCRIBED CRANE FLIES FROM FORMOSA AND LUZON (TIPULIDÆ, DIPTERA)

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

All but one of the new species of crane flies described in the present paper were collected in Formosa (Taiwan) by Dr. Teiso Esaki during his recent collecting trip (August to October, 1921) to that island. The majority of these species were collected in the high mountains, which support a rich endemic tipulid fauna. The interesting new *Pselliophora* was collected by Dean C. F. Baker in northern Luzon. My thanks are extended to Doctor Esaki and Dean Baker for the privilege of studying these highly important collections. The Formosan types are preserved in my collection through the generosity of Doctor Esaki.

Trichocera flavoides sp. nov.

General coloration pale yellow, the terminal segments of the palpi, the antennal flagellum, and the legs pale brown; wings pale yellow.

Female.—Length, 3.2 millimeters; wing, 3.5 to 3.6. Rostrum and basal segment of palpus yellow, the remainder of the palpi dark brown. Antennal scape light yellow, the flagellum pale brown. Head pale yellow.

Mesonotum almost white, the pleura pale yellow. Halteres pale yellowish white. Legs with the coxæ and trochanters pale yellow; remainder of the legs pale brownish testaceous. Wings with a pale yellow tinge; veins pale. Venation: Sc_1 ending opposite the fork of R_{2+3}; R_{2+3} about equal to the first section of R_2; basal deflection of R_{4+5} very short, oblique; cell 1st M_2

very narrow, the inner end acutely pointed; m-cu longer than m, almost in alignment with M_{3+4}, beyond midlength of cell 1st M_2; basal deflection of Cu_1 about one-half its length beyond the fork of M_{3+4}.

Abdomen pale yellow; ovipositor with the valves pale.

Habitat.—Formosa.

Holotype, female, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 17, 1921 (*T. Esaki*). Paratopotypes, 1 female, with the type; 1 female, August 19, 1921.

Trichocera flavoides is perhaps only a variety of *T. flava* Brunetti of northern India, but there are some venational and colorational characters that seem to be of more than subspecific importance. *Trichocera flava* is the same as *Paracladura gracilis* Brunetti, an earlier name, but as there is already a *Trichocera gracilis* Walker, the name *flava* should be used.

Libnotes subopaca sp. nov.

General coloration orange-yellow; femora obscure yellow, the tips broadly dark brown; wings with a strong fulvous tinge, the stigma and a small apical spot darker brown; basal deflection of Cu_1 at two-fifths the length of cell 1st M_2.

Male.—Length, 10 millimeters, wing, 13.7. Rostrum dark brown; palpi brownish black. Antennæ dark brown, the second scapal segment obscure brownish yellow. Head saturated fulvous yellow; vertex between the eyes narrow.

Mesonotal præscutum orange-yellow, the remainder of the notum and the pleura more yellow. Halteres dark brown, the base of the stem narrowly yellow. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips broadly dark brown; tibiæ yellow, the tips narrowly darkened; tarsi yellowish brown, the terminal segments dark brown. Wings with a strong fulvous tinge; stigma conspicuous, elongate, brown; extreme tip of the wing in cells 2d R_1, R_3, and R_5 narrowly infuscated; veins dark brown. Venation: Sc_2 at tip of Sc_1; r long, bent almost at a right angle; m and outer deflection of M_3 subequal in length, the inner ends of the cells in alignment; basal deflection of Cu_1 at two-fifths the length of cell 1st M_2.

Abdomen orange-yellow, the lateral line narrowly infuscated; hypopygium dark brown.

Habitat.—Formosa.

Holotype, male, Urai, altitude about 1,500 feet (about 450 meters), October 1, 1921 (*T. Esaki*).

Libnotes subopaca is most closely related to *L. opaca* Bezzi, of Luzon.

Dicranomyia tattakæ sp. nov.

General coloration gray, the mesonotal præscutum with three more or less confluent dark brown stripes; pleura with a narrow black longitudinal stripe; wings faintly tinged with gray; brown spots at arculus, at origin of Rs and at the stigma; veins beyond cell 1st M_2 short.

Male.—Length, about 5 millimeters; wing, 7.2. Rostrum and palpi brownish black. Antennæ dark brownish black throughout. Head light gray.

Mesonotal præscutum yellowish gray with three dark brown stripes, the anterior ends of the lateral stripes confluent with the median stripe, restricting the interspaces to linear stripes before the suture; humeral region clearer gray; scutum gray, the lobes dark brown; remainder of the mesonotum dark brown, sparsely pruinose. Pleura dark gray with a very narrow but conspicuous black longitudinal stripe extending from above the fore coxa to the base of the abdomen, passing immediately ventrad of the root of the halteres. Halteres obscure yellow, the knobs a little darker. Legs with the coxæ dark, sparsely pruinose; trochanters brown; femora brown, the extreme bases pale, the tips broadly blackened, the extreme apices indistinctly pale; tibiæ and metatarsi brown, the tips blackened; remainder of the tarsi black. Wings with a faint gray tinge, sparsely spotted with brown; a conspicuous spot at arculus; a second spot at origin of Rs; stigma small, subcircular in outline; narrow brown seams along the cord and outer end of cell 1st M_2; anal angle faintly infuscated; veins brown, those in the costal region a little more yellowish. Venation: Sc short, Sc_1 ending opposite the origin of Rs, Sc_2 at its tip; Rs feebly angulate at origin, not quite twice the deflection of R_{4+5}; cell 1st M_2 long and narrow, longer than any of the veins issuing from it, more than twice the distal section of Cu_1; basal deflection of Cu_1 before the fork of M, the distance a little longer than r-m.

Abdomen dark brown. Male hypopygium with the ventral pleural appendage large, produced into a conspicuous rostrum that bears two spines; mesal face of pleurite produced into a conical lobe, the mesal face and apex of which is setiferous.

Habitat.—Formosa.

Holotype, male, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 16, 1921 (*T. Esaki*).

Dicranomyia tattakæ is related to *D. basifusca* Alexander, of Japan.

Dicranomyia curvispina sp. nov.

General coloration obscure yellow; head black; wings with a strong brownish tinge, the stigma darker; Sc long, cell 1st M_2 closed; abdominal tergites dark brown, the sternites bicolorous; mesal pleural appendage of male hypopygium bearing a long, curved spine.

Male.—Length, 6 millimeters; wing, 7.5. Rostrum and palpi black. Antennæ dark brown, the flagellar segments elongate. Head dark brown.

Pronotum dark medially, obscure yellow laterally. Mesonotal præscutum shiny yellow, broadly infuscated on the cephalic margin; remainder of the mesonotum obscure yellow. Pleura yellow, the dorsal sclerites a little infuscated. Halteres elongate, brown, a little paler at the extreme base of the stem. Legs with the coxæ and trochanters yellow; femora pale brown, the tips broadly darkened; tibiæ and tarsi dark brown. Wings with a strong brown tinge; stigma oval, darker brown; veins dark brown. Venation: Sc moderately long, Sc_1 ending just before one-third the length of Rs, Sc_2 at its tip; Rs long, almost straight; r at tip of R_1; inner end of cell R_3 far proximad of cell R_5; cell 1st M_2 pentagonal, gently widened distally; m about two-thirds the outer deflection of M_3; distal section of M_{1+2} longer than cell 1st M_2; basal deflection of Cu_1 one-half longer than Cu_2, situated some distance beyond the fork of M.

Abdominal tergites dark brown; sternites obscure yellow, the incisures conspicuously dark brown, increasing in extent on the subterminal segments. Male hypopygium obscure brownish yellow. Mesal pleural appendage bearing a single, very long and conspicuous spine far before the tip, this strongly bent near one-third its length, the apical two-thirds appearing as a long, black spine.

Habitat.—Formosa.

Holotype, male, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 18, 1921 (*T. Esaki*).

Molophilus arisanus sp. nov.

General coloration brown; antennæ short; wings uniformly tinged with brown; vein 2d A ending far beyond the basal deflection of Cu_1; male hypopygium with the inner pleural appendage bifid.

Male.—Length, 3.1 millimeters; wing, 4.5. Rostrum pale brown, the palpi brownish black. Antennæ short, if bent backward not attaining the wing root, pale brownish testaceous, the basal segment darker. Head grayish brown.

Mesonotum brown, the præscutum darker brown medially, the lateral margins narrowly whitish. Pleura pale brown with indications of a darker brown, longitudinal stripe. Halteres yellow. Legs with the coxæ and trochanters yellow, the posterior coxæ dark; remainder of the legs dark brown. Wings tinged with brown, the macrotrichiæ dark brown. Venation: Vein 2d A elongate, ending far beyond the basal deflection of Cu_1.

Abdomen dark brown, the hypopygium only a little paler. Male hypopygium with the outer pleural appendage slender, slightly curved to the long, acute, black tip; inner appendage complex, before the apex split into two long spines.

Habitat.—Formosa.

Holotype, male, Arisan, altitude 7,362 feet (about 2,250 meters), August 24, 1921 (*T. Esaki*).

Erioptera (Erioptera) rogersi sp. nov.

General coloration pale yellowish white; antennæ yellow, the first scapal segment dark; femora pale fulvous with a snowy white ring before the tips; tibiæ yellow, the bases narrowly white; wings pale fulvous yellow, narrowly darker along the cord.

Male.—Length, 4.5 millimeters; wing, 4.6. Rostrum and palpi pale brown. Antennæ with the basal segment pale brown, the remainder of the organ light yellow. Head pale cream color, covered with a microscopic white bloom; eyes of male large, contiguous beneath.

Pronotum and mesonotum almost white, immaculate. Pleura pale yellowish white. Halteres pale yellow. Legs with the coxæ and trochanters concolorous with the pleura; femora pale fulvous, paler at base, immediately before the tips with a narrow, snow-white band which is provided with snowy white setæ, the extreme apex narrowly darkened; tibiæ yellow, the extreme base snowy white; tarsi yellow. Wings pale fulvous yellow with indications of a broad, paler band before the cord, the latter narrowly seamed with darker; veins yellow with fulvous macrotrichiæ, darker colored in the infuscated area. Venation: As in the subgenus, vein 2d A strongly sinuous.

Abdomen pale whitish yellow, the sternites beyond the base a little more saturated; a narrow, brown, lateral line on the basal half of the abdomen. Male hypopygium with the pleurites unusually elongate, each pleural appendage very long and slender, the acute tip slightly curved. The gonapophyses appear as two short, curved horns on either side, the tips directed mesad.

Habitat.—Formosa.

Holotype, male, Kanshirei, altitude about 1,000 feet (about 300 meters), September 10, 1921 (*T. Esaki*).

This handsome *Erioptera* is named in honor of my friend Prof. J. Speed Rogers, in appreciation of his critical studies on the Nearctic species of *Erioptera.*

Gnophomyia brevicellula sp. nov.

General coloration dark brown; antennæ of the male elongate, densely pubescent; wings grayish subhyaline; r-m before the fork of Rs; the veins issuing from cell 1st M_2 very long, the shortest two and one-half times the length of the cell; basal deflection of Cu_1 at midlength of the cell.

Male.—Length, 5.5 millimeters; wing, 6. Rostrum and palpi obscure brownish yellow. Antennæ elongate, if bent backward extending nearly to the base of the third abdominal segment, light brown, the elongate flagellar segments densely clothed with an erect white pubescence. Head brown.

Pronotum obscure yellow laterally. Mesonotum dark brown, rather shiny. Pleura brown with a narrow, ventral, gray, longitudinal stripe; sternites testaceous. Halteres dark brown. Legs with the coxæ and trochanters testaceous; remainder of the legs dark brown. Wings grayish subhyaline, the veins dark brown; stigma little evident. Venation: Sc long, Sc_1 ending beyond the fork of R_{2+3}; Rs gently arcuated, r-m connecting with Rs about one-half its own length before the fork of Rs; basal section of R_2 a little shorter than r-m; cell 1st M_2 small, elongate, widened distally, m a little shorter than the outer deflection of M_3; veins issuing from cell 1st M_2 very long, the shortest (distal section of Cu_1) two and one-half times the cell; basal deflection of Cu_1 near midlength of the cell.

Abdominal tergites dark brown, the sternites paler. Male hypopygium with the longest pleural appendage a long, slender, somewhat flattened blade.

Habitat.—Formosa.

Holotype, male, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 16, 1921 (*T. Esaki*).

Xipholimnobia formosensis sp. nov.

General coloration pale brown, the mesonotal scutellum and postnotum dark brown, dusted with gray; pleura brown with a narrow, longitudinal, silvery gray stripe; legs brown; wings with a uniform brown tinge; distal section of R_1 entirely atrophied; abdomen dark brown, the valves of the ovipositor a little less than one-half the length of the abdomen.

Female.—Length, about 4 millimeters: wing, 3.5. Rostrum and palpi brown. Antennæ pale brown. Head brown.

Mesonotal præscutum pale brown, the median area of the scutum light gray, the lobes concolorous with the præscutum; scutellum and postnotum dark brown, sparsely dusted with gray. Pleura brown with a narrow, longitudinal, silvery gray stripe extending to the base of the abdomen. Halteres with the sternites obscure yellow, the knobs dark brown. Legs with the coxæ small, testaceous; trochanters testaceous; remainder of the legs brown. Wings with a uniform brownish tinge; stigma lacking; veins pale brown. Venation: Sc long, Sc_1 ending about opposite four-fifths the length of the long Rs, Sc_2 subobsolete, a short distance from the tip of Sc_1, the latter alone about equal to m; distal section of R_1 entirely atrophied as in the genus, the vein appearing to end in R_2; r provided with two macrotrichæ; Rs in alignment with R_{2+3}; basal section of R_2 perpendicular; inner ends of cells R_3, R_5, and 1st M_2 in alignment; cell 1st M_2 gently widened distally, m and the outer deflection of M_3 subequal; basal deflection of Cu_1 near four-fifths the length of the caudal face of cell 1st M_2.

Abdomen dark brown, the valves of the ovipositor concolorous. Ovipositor with the valves a little less than half the length of the abdomen, long and straight as in the genus.

Habitat.—Formosa.

Holotype, female, Kanshirei, altitude about 1,000 feet (about 300 meters), September 10, 1921 (*T. Esaki*).

Xipholimnobia formosensis agrees closely with the genotype, *X. terebrina* Alexander, of West Africa, and there is no doubt as to the correctness of the generic reference. The chief venational peculiarities of the genus are the atrophy of the distal

section of R_1 with the corresponding appearance of vein R_1 ending in vein R_2 as in most Cylindrotominæ, and the position of the basal deflection of Cu_1 near the outer end of cell 1st M_2. The valves of the ovipositor in the present species are very long and slender, but not so excessively so as in the genotype.

Trentepohlia (Trentepohlia) pulchripennis sp. nov.

Head dark brown, the anterior part of the vertex obscure yellow; antennæ dark brown; mesonotum light yellow, the postnotum dark brown; pleura broadly dark brown; wings whitish hyaline with three conspicuous brown crossbands variegated with white spots.

Male.—Length, 5.5 millimeters; wing, 5.6.

Female.—Length, 6 millimeters; wing, 5.3.

Rostrum and palpi dark brown; mouth parts obscure yellow. Antennæ dark brown, the basal flagellar segments feebly bicolorous, the bases paler than the remainder of each segment. Head dark brown, the anterior part of the vertex obscure yellow.

Pronotum brownish black. Mesonotal præscutum light yellow, unmarked; scutum and scutellum obscure brownish yellow; postnotum dark brown with a small, obscure yellow, median spot before the caudal margin. Pleura dark brown, the sternum and the dorsal pleurites obscure yellow. Halteres yellow, the knobs dark brown. Legs with the fore coxæ brown; hind coxæ yellow, brown basally; remainder of the legs obscure yellow; no conspicuous armature on femora or tibiæ. Wings whitish hyaline with a very heavy dark brown pattern; base pale; a basal brown band across the wing, from just beyond h, including almost all of cell 2d A; a very broad brown band at the level of the origin of Rs, extending from before Rs to just beyond the tip of Sc_1, including cells C, Sc, 1st R_1 (the latter with a pale spot in the male), the outer ends of cells R and M except large white blotches; in cells Cu and 1st A the band is much paler, grayish; remainder of the cord and the base of cell R_3 conspicuously darkened; the apical band is entirely separate from the middle band, including the distal two-thirds of cell 2d R_1, all of cell R_2 except an oval spot near the tip of R_2 and the extreme apex; the distal two-thirds of cell R_3 except the extreme apex; all of cell R_5 except an oval spot in the base and the extreme apex; outer two-thirds of cell M_2 darkened; outer angle of cell Cu_1 slightly paler brown; veins dark brown in the infuscated areas, yellowish elsewhere.

Venation: r very short, less than the tip of R_1 beyond it; petiole of cell R_5 a little longer than the basal section of M_{1+2}.

Abdomen dark brown, the basal sternites and the hypopygium obscure brownish yellow. Ovipositor with the valves conspicuously yellow.

Habitat.—Formosa.

Holotype, male, Musha, altitude about 3,500 feet (about 1,050 meters), August 15, 1921 (*T. Esaki*). Allotype, female, Sumaän, altitude about 2,500 feet (about 760 meters), August 21, 1921 (*T. Esaki*).

Trentepohlia pulchripennis is related to *T. ornatipennis* Brunetti, of southwestern India, and *T. pictipennis* Bezzi, of Luzon, in the general character of the wing pattern, but is distinct from any described species.

Trentepohlia (Mongoma) esakii sp. nov.

Female.—Length, 9 millimeters; wing, 7.7. Allied to *T.* (*M.*) *pennipes* (Osten Sacken), differing as follows: Head dark gray, the occiput obscure yellow. Mesonotal præscutum brown, the lateral margins and humeral angles narrowly obscure yellow. Legs with the femora pale brown, the tips rather narrowly (1 millimeter) white; tibiæ dark brown, the tips broadly white, on the middle legs occupying about the distal third of the segment; tarsi white. The white distal third of the midtibia is distinctly fringed with conspicuous white setæ as in the *pennipes* group. Midfemur with about nine stout spines near the base, with other additional spines arranged in a row, these becoming more elongate and more distant from one another toward the outer end of the sclerite, the apical ones appearing bristlelike. Wings whitish subhyaline; veins brown. Venation: Sc_1 about equal to R_2; r a little more than its length before the fork of R_{2+3}; R_2 gently sinuous.

Habitat.—Formosa.

Holotype, female, Musha, altitude about 3,500 feet (about 1,060 meters), August 15, 1921 (*T. Esaki*).

Trentepohlia esakii is named in honor of the collector. It is related to *T. pennipes* (Osten Sacken) and *T. tarsalis* Alexander in the feathered midtibial apices, but is very distinct in the conspicuous white femoral tips.

Ceratocheilus taiwanicola sp. nov.

General coloration dark brown; mesonotal præscutum yellowish gray with three dark brown stripes; legs dark brown; abdomen uniformly dark brown, only the hypopygium paler.

Male.—Length, excluding rostrum, 4.6 millimeters; wing, 5.4. Rostrum elongate, brownish black. Antennæ dark brown. Vertex between the eyes broad, dark brown, the anterior portion and a narrow margin adjoining the eyes light gray.

Mesonotal præscutum yellowish gray with three conspicuous dark brown stripes; scutum dull gray, the lobes brown; remainder of the mesonotum dark gray. Pleura dark gray, the dorsal sclerites indistinctly darker; sternites more plumbeous. Halteres testaceous. Legs with the coxæ and trochanters pale brownish testaceous; remainder of the legs dark brown, only the femoral bases narrowly paler. Wings pale grayish subhyaline; veins pale brown. Venation: Sc_1 ending a short distance beyond the origin of Rs, Sc_2 a slightly greater distance before this origin; basal deflection of Cu_1 about one-fifth its length beyond the fork of M.

Abdomen dark brown, only the hypopygium paler.

Habitat.—Formosa.

Holotype, male, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 18, 1921 (*T. Esaki*).

Genus **TAIWANOMYIA** novum

Antennæ elongate, in the male twice as long as the body, in the female extending to beyond the wing root, 16-segmented. Tuberculate pits elongate-oval, lying close together a short distance back from the cephalic margin of the præscutum. Tibiæ spurred; claws small, simple; empodia distinct. Wings with Sc long, Sc_1 ending a short distance before r-m, Sc_2 a short distance from the tip of Sc_1; Rs angulated or spurred at origin; R_{2+3} very long, about equal to or longer than its fork; r close to the fork of R_{2+3} and about twice its length from the tip of R_1; deflection of R_{4+5} very long, subequal to Rs; cell M_1 lacking; outer deflection of M_3 long and arcuated; basal deflection of Cu_1 from one and one-half to nearly twice its length before the fork of M; vein 2d A ending beyond the level of the origin of Rs; arculus complete. Ovipositor with all valves long and straight, the sternal valves a little exceeding the stouter tergal valves.

Genotype, *Taseocera fragilicornis* Riedel, of Formosa.

Riedel failed to detect the tibial spurs and placed this fly in the tribe Eriopterini. The genus is a very isolated one, and no immediate relatives can be indicated. The chief venational

peculiarities are the long deflection of R_{4+5} which is approximately as long as Rs and the position of the basal deflection of Cu_1 which is far before the fork of M. *Taseocera* Skuse is well distinguished by the extreme brevity of vein 2d A.

Taiwanomyia fragilicornis (Riedel).

Taseocera fragilicornis RIEDEL Archiv für Naturgeschichte, 82 Jahrg., Abt. A, 5 Heft (1916) 112, 113.

Riedel had only a single male. I have before me seven females from Kuraru, Formosa, August 30 to September 5, 1921, collected by Teiso Esaki, one of which is here designated as allotypic.

Allotype, female, length, 4 millimeters; wing, 3.9 to 4. Differs from the description of the male as follows:

Basal segment of the scape brownish black, the second segment conspicuously cream-yellow; antennæ shorter, the flagellar segments elongate-cylindrical with short verticils. Pleura brown with a narrow, blackish, longitudinal stripe. Legs with the coxæ and trochanters dark brown; femora light brown, gradually passing into dark brown, the extreme tips pale; tibiæ brown, the tips narrowly darkened, the extreme bases white; tarsi pale brown. Wings grayish subhyaline, heavily spotted and clouded with brown, there being from five to eight larger areas in cell C, the more-conspicuous ones extending caudad into cell Sc. Vein Sc long, Sc_1 ending about opposite three-fourths the length of the deflection of R_{4+5}, Sc_2 about one-third Sc_1; r about twice its length from the tip of R_1; cell 1st M_2 narrow at the proximal end which is only about one-half as long as r-m; m about one-third to one-fourth the outer deflection of M_3; cell 1st M_2 approximately as long as the longest vein issuing from it (M_{1+2}); cell Cu_1 very deep, due to the basal recession of the deflection of Cu_1.

Allotype, female, Kuraru, Formosa, September 1, 1921 (*T. Esaki*).

Limnophila illustris sp. nov.

Related to *L. ochracea* Meigen; mesonotal præscutum pale brown with three yellowish brown stripes; thoracic pleura with a narrow, dark brown, longitudinal stripe; wings with a strong brownish tinge; anterior arculus nearly atrophied; abdominal sternites yellow, ringed with dark brown.

Female.—Length, 7 millimeters; wing, 7.6. Rostrum and palpi brown. Antennæ rather elongate, if bent backward at-

taining the wing root, dark brown, the first flagellar segment pale on the basal third. Head pale yellowish brown.

Pronotum pale. Mesonotal præscutum pale brown, the three usual stripes more yellowish brown; tuberculate pits lacking; remainder of the mesonotum brown. Pleura brownish yellow with a conspicuous dark brown longitudinal stripe extending to the base of the abdomen. Halteres with the stem pale brown, the base narrowly yellow, the knobs dark brown. Legs with the coxæ concolorous with the pleura; trochanters similar, infuscated apically; remainder of the legs brown, the terminal tarsal segments darker brown. Wings with a strong brown tinge; stigma elongate-oval, darker brown; a very faint infuscation along the cord and at the origin of Rs; veins dark brown. Venation: Sc_1 ending opposite the end of Rs, Sc_2 its own length from the tip of Sc_1; Rs relatively short, feebly angulated near origin; R_{2+3} moderately elongate, gently arcuate, about equal to the first section of R_2; r a little more than its own length from the tip of R_1; inner ends of cells R_3, R_5, and 1st M_2 about in alignment; cell 1st M_2 rather short-pentagonal; petiole of cell M_1 rather short, about equal to the second section of M_{1+2} basal deflection of Cu_1 at three-fifths the length of cell 1st M_2; anterior arculus almost obliterated.

Abdominal tergites dark brown; sternites pale yellow, each ringed before midlength with dark brown.

Habitat.—Formosa.

Holotype, female, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 17, 1921 (*T. Esaki*).

Elephantomyia major uniformis subsp. nov.

Male.—Length, excluding rostrum, 9.5 millimeters; wing, 8.5. Differs from typical *E. major* Alexander, of Kotosho Island, as follows: Smaller. Antennæ black throughout. Mesonotal præscutum reddish brown with a conspicuous black median stripe, broadest in front, narrowed behind, becoming obsolete near the suture. Pleura conspicuously light gray pruinose. Legs with the coxæ infuscated on their outer faces. Abdominal tergites dark brown; basal sternites indistinctly bicolorous, the subterminal segment entirely black.

Habitat.—Formosa.

Holotype, male, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 16, 1921 (*T. Esaki*).

Tricyphona symphyletes sp. nov.

In its general appearance close to *T. kuwanai* Alexander, but in the structure of the male hypopygium more like *T. trispinosa* Alexander.

Male.—Length, about 8 millimeters; wing, 9.3. Smaller than *T. kuwanai.* Cephalic lateral portion of scutal lobes with a semilunar dark brown spot, the posterior portion of the lobes less distinctly infuscated; scutellum and postnotum yellow. Legs light yellow, the segments not distinctly darkened at tips. Wings with the costal streaks as in *T. kuwanai;* a conspicuous dark brown seam along the basal fourth of M; a pale brown seam on the basal deflection of Cu_1, the remainder of the cord nearly clear; the brown oblique cloud extends across the wing to m but does not reach the margin as in *T. trispinosa.* Venation: r-m connecting with Rs nearly its own length before the fork; petiole of cell R_3 short, a little less than one-half m; basal portion of R_{2+3} perpendicular, bent at a strong angle, the free portion of R_2 very short, R_{2+3} being bent close to R_1 at this point widening cell R_3; cell R_4 very wide near mid-length, correspondingly narrowed at the distal end; m present, transverse, connecting M_2 with M_3, the latter just beyond mid-length; basal deflection of Cu_1 immediately beyond the fork of M.

Male hypopygium with but three black spines on the pleural appendage as in *T. trispinosa,* the notch between these and the apical point circular in outline. Gonapophyses with the lateral margin almost straight to the apex, not bulged outward before the apex as in *T. kuwanai.*

Habitat.—Formosa.

Holotype, male, Musha, altitude about 3,500 feet (about 1,060 meters), August 20, 1921 (*T. Esaki*).

Phalacrocera formosæ sp. nov.

Head shiny dark brown, the inner margin of the eyes obscure greenish; præscutum shiny obscure yellow with three dark brown stripes, the median stripe split by a pale line; scutal lobes and scutellum brownish black; pleura and sternum pale green; wings with a strong brown tinge; cell 2d A narrow; abdominal tergites brown, the sternites obscure brownish yellow.

Female.—Length, 10 millimeters; wing, 11.2. Frontal prolongation of the head very short; palpi greenish brown. An-

tennal scape pale green, the flagellum dark brown; flagellar segments beyond the fourth cylindrical with conspicuous verticils. Head shiny dark brown, the inner margin of the eyes obscure greenish.

Mesonotal præscutum shiny obscure yellow with three dark brown stripes, the median stripe broadly split by a pale line; scutum obscure brownish yellow, each lobe with a conspicuous dark brownish black blotch; scutellum black; postnotum obscure brownish yellow. Pleura and sternum pale greenish. Halteres elongate, dark brown, the extreme base of the stem greenish. Legs with the coxæ and trochanters pale green; tibiæ and tarsi brown, the tips faintly darkened; tarsi dark brown. Wings with a strong brown tinge; stigma small and narrow, pale brown; veins dark brown, very conspicuous. Venation: Sc_2 not far from the tip of Sc_1; tip of R_1 barely indicated; R_2 entirely atrophied; deflection of R_{4+5} longer than r-m; m and outer deflection of M_3 subequal; basal deflection of Cu_1 about two-thirds its length beyond the fork of M; cell 2d A very narrow for a member of this genus.

Abdominal tergites dark brown, the sternites obscure brownish yellow.

Habitat.—Formosa.

Holotype, female, Tattaka, altitude about 7,400 feet (about 2,250 meters), August 19, 1921 (*T. Esaki*).

Pselliophora igorota sp. nov.

General coloration orange; antennal flagellum with only nine segments; tibiæ yellow with about the middle half dark brown; wings yellow, the cells beyond the cord a little darker; abdominal segments orange.

Female.—Length, about 15 millimeters; wing, 15. Frontal prolongation of the head orange; palpi reddish brown, the terminal segment dark brown. Antennæ with only eleven segments as in *P. bicinctifer*, the subterminal flagellar segments almost globular; antennæ orange-yellow throughout. Head obscure orange.

Mesonotal præscutum orange-yellow with three ill-defined reddish stripes, the median stripe broader and better defined; remainder of the mesonotum obscure orange. Pleura obscure orange. Halteres obscure orange. Legs with the coxæ and trochanters obscure orange; femora yellow with the extreme tips indistinctly darker; tibiæ obscure yellow with more than the central half dark brown; metatarsi brownish yellow, the

tips darkened; tarsi dark brown. Wings with a strong yellow tinge, the cells beyond the cord a very little darker; stigma small, oval, dark brown; veins pale brown. Venation: r on R_2 immediately beyond the fork of R_{2+3}; petiole of cell M_1 very short, about equal to r-m.

Abdominal tergites orange, the basal segments with dark egg masses showing through the chitin.

Habitat.—Luzon.

Holotype, female, Baguio, Benguet, Mountain Province (*C. F. Baker*). Type returned to Dean Baker.

Pselliophora igorota requires comparison only with *P. bicinctifer* Alexander, from the same locality; the latter species has the general coloration black, the first scapal segment brownish black, the tips of the tibiæ dark brown; wings with the apex more conspicuously infuscated.

ACHILIXIUS, A NEW GENUS, CONSTITUTING A NEW FAMILY OF THE FULGOROIDEA (HOMOPTERA)

By F. Muir

Of the Hawaiian Sugar Planters' Experiment Station, Honolulu

ONE PLATE

In 1914 Melichar described a Philippine homopteron as *Syntames tubulifer*.[1] In 1917 I rejected this species from the Derbidæ [2] because of the long apical joint of the rostrum and suggested that it represented a new genus of Cixiidæ.

I have recently been reconsidering the classification of the Fulgoroidea, with the result that I am unable to place this species in either the Cixiidæ or the Achilidæ, although it has certain characters of both of these families. The venation of the tegmen would place it in the Achilidæ, the claval vein running into the apex of the clavus which is roundly closed; but the male genitalia are quite different from all of the Achilidæ with which I am acquainted. The general facies of the insect also differs considerably from that of the Achilidæ, the body not being flattened, and the tegmina are fairly steeply tectiform. While the male genitalia might find a place in the Meenoplinæ (Cixiidæ) and the abdominal appendages are similar to those found in *Benna* and *Bennaria*, the venation is not of the cixiid type. The type of male genitalia found in the Derbidæ is distinct from that of all other fulgorids and will not allow of the species under consideration being placed therein. To place it in any one of these three families would only lead to confusion by breaking down good family characters. Therefore, I consider it better to place it in a family by itself whose nearest relationship would be with the Meenoplinæ (Cixiidæ).

Family ACHILIXIIDÆ novum

Genus ACHILIXIUS novum

Vertex and face in profile forming a curve without any division between them; in dorsal view the vertex is much wider

[1] Philip. Journ. Sci. § D 9 (1914) 269.
[2] Philip. Journ. Sci. § D 12 (1917) 59.

than long; the median and lateral carinæ continued on to the face, which is but very slightly narrowed between the eyes. Clypeus tricarinate, the median carina obscure. Antennæ reaching to base of clypeus, first segment as wide as long, second narrow at base, thickened on apical portion. Posterior margin of pronotum very shallowly emarginate, obscurely tricarinate, the lateral carinæ widely diverging on posterior half and joining hind margin near tegulæ; the three carinæ of mesonotum straight, parallel, obscure. In the tegmina Sc and R separate about one-third from base of tegmen; four branches of R at apex; Cu1 and Cu1a touch for a short distance before apex. Near the base of the abdomen there are two pairs of processes arising from the pleura; the first two processes are longer than broad, narrowed at base, slightly flattened, and bear two depressions on apex; the second two are not so long and appear more like swellings on the pleura than processes, and each bears a small depression on apex. The pygofer differs from that of all the Achilidæ with which I am acquainted; it is compressed laterally and has a chitinous bar across the middle to which the base of the ædeagus is attached, thus allowing it movement around the point of attachment but not allowing it to be protruded. I know of no other fulgorid with this feature. In certain respects this type of genitalia approaches the type found in the Meenoplinæ of the Cixiidæ.

Type, *Achilixius singularis* sp. nov.

Achilixius singularis sp. nov. Plate 1, fig. 1.

Male.—Length, 2.7 millimeters; tegmen, 4. Brown; frons, vertex, and pronotum dull, with minute punctures, mesonotum shiny, with very few punctures; antennæ, lateral carinæ of frons, lateral portions of pronotum, legs, abdominal pleura, and pleural processes lighter brown or yellow. Tegmina brown, veins same color as membrane, except the apical veins, which are light, no tubercles or macrotrichæ; wings fuscous brown with dark veins.

Pygofer large, compressed laterally, opening longer than broad, lateral margins slightly angular in middle, no anal emargination, basal foramen comparatively small. Anal segment large, much longer than broad, subparallel sided, apex slightly angular in middle, the lateral angles projecting; dorsal surface flattened on basal two-thirds, rounded on apical third, anus at base, ventral surface concave. Genital styles long, slender, subspiniform, flattened slightly on basal third where there is a subquadrate process and a small curved spine on the outer

margin. Ædeagus cultriform, the dorsal margin straight, broad, the ventral edge narrow and formed of two thin laminæ between which is the orifice. The bar across pygofer strong, arising from the angulation on the middle of lateral margins.

LUZON, Mountain Province, Baguio (*Baker*), 1 male. Type No. 1045.

Achilixius tubulifer (Melichar). Plate 1, figs. 2 and 3.

Syntames tubulifer MELICHAR, Philip. Journ. Sci. § D 9 (1914) 269, pl. 1, fig. 2; MUIR, Philip. Journ. Sci. § D 12 (1917) 59.

Male pygofer small, laterally compressed, margins entire, crossbar not very strong or chitinous. Anal segment short and broad, in dorsal view nearly round, with an obscure emargination at apex. Genital styles small and narrow, apex rounded, with the inner edge drawn out into a small point and a small projection on the outer corner. Ædeagus subcultrate, with the orifice down the ventral or anterior edge.

LUZON, Laguna Province, Los Baños, Mount Maquiling, and Mount Banahao (*Baker* and *Muir*), a number of specimens.

Achilixius sandakanensis sp. nov. Plate 1, fig. 4.

Male.—Length, 2 millimeters; tegmen, 3. In coloration this species is similar to *A. singularis*, but the general color is darker and the legs are marked with obscure fuscous bands.

Pygofer larger than in *A. tubulifer*, the ventral edge produced roundly, the crossbar nearer to the anal segment than in *A. singularis*, lateral margins entire or very slightly sinuous. Anal segment large, anus about one-third from base, in dorsal view much longer than broad, apex rounded. Genital styles flat and broad, subequal in width throughout, apex rounded with a strong, slightly curved spine on the inner surface, on the outer margin near apex slightly rounded. Ædeagus strong, chitinous, subcultrate with the base, wide and curved upward nearly at a right angle; apex acute, produced into two fine points; orifice along ventral margin.

Female.—Length, 2.2 millimeters; tegmen, 3. In color similar to male.

BORNEO, Sandakan (*Baker 10172*), 5 males and 2 females. Type No. 1046.

Achilixius davaoensis sp. nov. Plate 1, fig. 5.

Male.—Length, 2.3 millimeters; tegmen, 3.5. In coloration similar to *A. singularis*, but the light color at apex of veins not so distinct.

Pygofer much longer ventrally than dorsally, margin entire, ventral edge straight, not produced. Anal segment fairly large, longer than broad; apex rounded, with a minute emargination in middle. Genital styles flat, width subequal to apex which is rounded; on the dorsal margin near apex there is a small, flattened, slightly curved, pointed projection. Crossbar nearer the anal segment than in *A. singularis*. Ædeagus formed of a single plate, or keel, on ventral half and of two rounded flanges on dorsal half, in profile the dorsal flanges project slightly beyond apex and are rounded in outline, the ventral edge nearly straight to apex which is curved, the base projects dorsad and laterad where it is attached to the crossbar; the orifice appears to be on the dorsal aspect between the flanges.

MINDANAO, Davao (*Baker*), 2 males and 2 females. Type No. 1047.

The types have been deposited in the collection of the Hawaiian Sugar Planters' Experiment Station and bear their type numbers; paratypes are retained in the Baker collection.

ILLUSTRATION

PLATE 1

FIG. 1. *Achilixius singularis* sp. nov.; pygofer, lateral view.
2. *Achilixius tubulifer* (Melichar); pygofer, lateral view.
3. *Achilixius tubulifer* (Melichar); left tegmen.
4. *Achilixius sandakanensis* sp. nov.; *a*, pygofer and anal segment, lateral view; *b*, ædeagus and genital styles, lateral view.
5. *Achilixius davaoensis* sp. nov.; ædeagus and left genital style, lateral view.

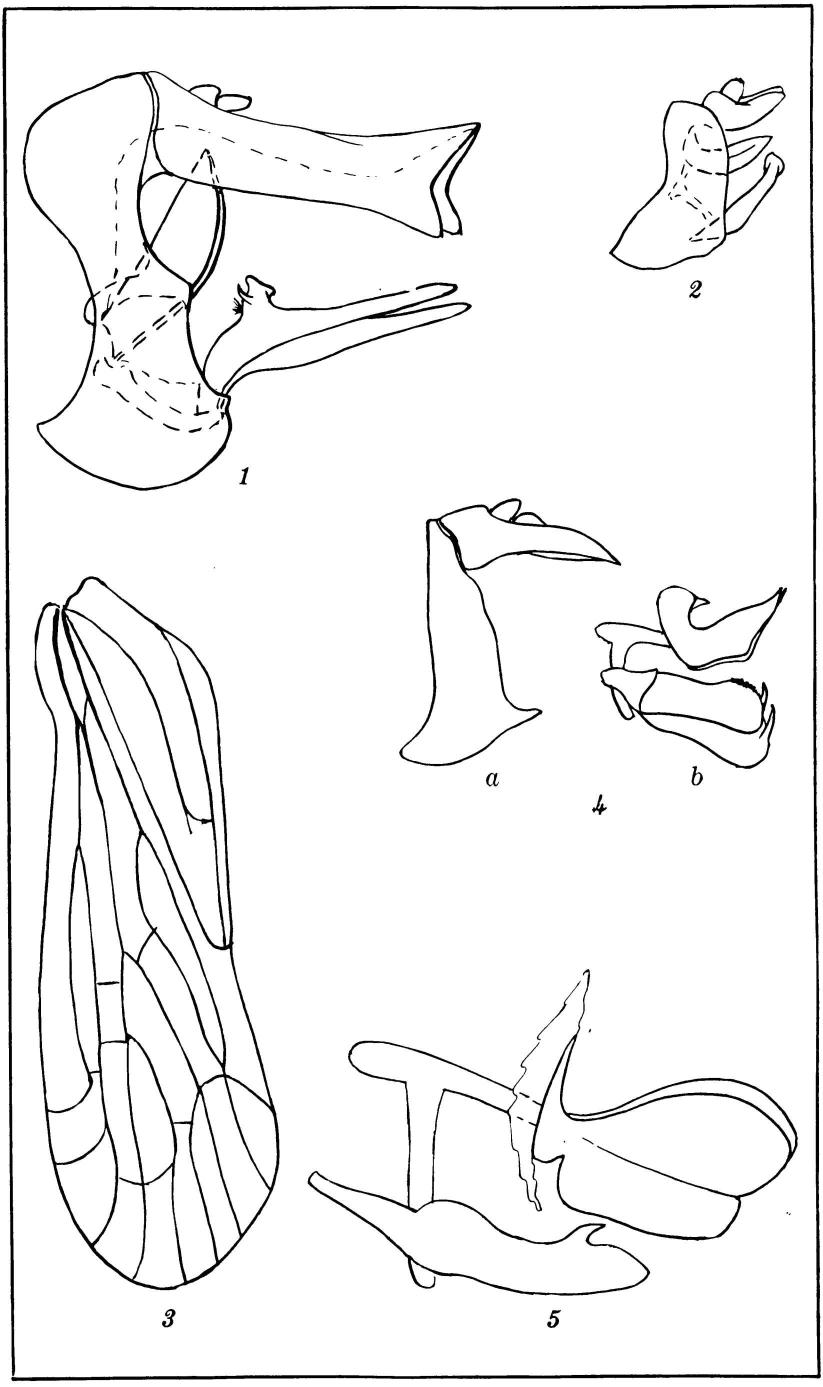

PLATE 1.

INDO-MALAYISCHE RHYNCHITINEN (CURCULIONIDÆ)

II, ZEHNTER BEITRAG ZUR KENNTNISS DER CURCULIONIDEN

Von Eduard Voss

Waldsiedlung Spandau, Germany

Genus RHYNCHITES Schneider

Uebersicht der Untergattungen.

a^1. Russel kräftig, kurz und gedrungen, kaum länger als das Halsschild; Augen kleiner als der Rüssel an seiner schmalsten Stelle; Flügeldecken meist länglich, gestreckt.............................. **Lasiorhynchidius** subg. nov.

a^2. Rüssel länger, schlank; Flügeldecken selten gestreckt: dann ist der Rüssel lang.

b^1. Stirn zwischen den Augen breiter als der Rüssel vor der Basis; Augen klein und kräftig vorgewölbt.

c^1. Tibien normal, schlank, zur Spitze wenig verbreitert; Hintertibien höchstens mit dünnem, geradem Dornfortsatz. **Auletomorphus subg. nov.**

c^2. Tibien anormal, gedrungen, und zur Spitze stark verbreitert; Hintertibien mit breitem Fortsatz. Körper gestreckt. **Piazorhynchites subg. nov.**

b^2. Stirn so breit wie der Rüssel an der Basis; Augen mässig oder garnicht vorgewölbt. Das zweite Geisselglied nicht länger als das Schaft- und erste Geisselglied zusammen.

d^1. Augen vorgewölbt .... **Involvulus Seidlitz.**

d^2. Augen Kaum aus der Kopfwölbung vortretend. **Metarhynchites subg. nov.**

Subgenus Lasiorhynchidius novum

Rhynchites curtirostris sp. nov.

Kopf breit und plump, fast quadratisch; Schläfen parallel; Punktierung fein, zerstreut auf dem Scheitel, nach hinten zu dichter. Stirn doppelt so breit als der Rüssel an seiner schmalsten Stelle. Rüssel kaum länger als das Halsschild, auf der Spitzenhälfte oben glatt; vor der Basis mit zwei breiten am Grunde runzlig punktierten Längsgruben, welche die Stirn mit angreifen, sie werden durch einen Mittelkiel getrennt. Fühler kurz hinter der Rüsselmitte eingelenkt. Schaftglied unbedeutend kürzer als das erste Geisselglied, letzteres doppelt so lang wie breit; das

zweite und dritte Glied am längsten, etwas länger als das erste Glied. Keule kräftig, das erste Glied derselben nicht ganz so lang wie das sechste und siebente Geisselglied zusammen; das zweite Glied wenig kürzer; das dritte Glied am kürzesten, gut anderthalbmal so lang wie breit. Halsschild so lang wie breit, fein gerunzelt, seitlich nur sehr schwach und gleichmässig gerundet, die grösste Breite liegt hinter der Mitte. Flügeldecken seitlich fast parallel, hinter den Schultern seitlich etwas eingezogen, fast doppelt so lang wie breit. Punktstreifen mässig kräftig, die Punkte stehen etwas entfernt. Der verkürzte Seitenstreifen vereinigt sich erst kurz vor der Spitze mit dem Randstreifen. Zwischenräume so breit wie die Streifen und sehr fein punktiert. Alle Tibien grade. Mittel- und Hintertibien kurz und gedrungen, Vordertibien schlanker und länger.

Färbung gelbbräunlich, Fühler und Beine rotgelb. Unterseite schwarzbraun; Keule, Tarsenspitzen, sowie die Naht der Decken schwarz. Behaarung sehr kurz, anliegend mit untermischten, längeren, aufstehenden Haaren. Länge, 4 Millimeter.

MINDANAO, Dapitan (*Baker*), 1 Exemplar.

Rhynchites dapitanus sp. nov.

Kopf länger als breit; nur äusserst fein und zerstreut punktiert; Augen stark vorgequollen. Stirn zwischen den Augen breiter als der Rüssel vor der Basis. Dieser beim Männchen kürzer, beim Weibchen so lang wie das Halsschild; Basalhälfte mehr oder weniger längsgekielt. Fühler des Männchens kurz hinter, des Weibchens in der Mitte des Rüssels eingelenkt. Männchen: Schaft- und erstes Geisselglied länglich oval, länger als breit, ersteres etwas kräftiger und länger als das letztere; das zweite und dritte Glied etwas länger, gleichlang, und wie die nachfolgenden Glieder verkehrt kegelförmig; das vierte bis siebente Glied so lang wie das erste. Keule kräftig; das erste Glied fast so lang wie die drei letzten Geisselglieder zusammen. Weibchen: Fühler viel kräftiger und gedrungener, das siebente Geisselglied fast quer. Halsschild etwas breiter als lang, seitlich schwach gerundet, zum Vorderrand etwas mehr verschmälert als zur Basis. Punktierung sehr fein und wenig dicht, hinten undeutlich verrunzelt. Flügeldecken des Männchens fast doppelt so lang wie breit, des Weibchens kürzer; seitlich fast parallel. Punktstreifen sehr kräftig, die Punkte stehen sehr dicht. Zwischenräume hinter der Basis sehr schmal, nach hinten zu breiter werdend. Der verkürzte Seitenstreifen vereinigt sich mit dem Randstreifen kurz hinter der Mitte.

Färbung rotgelb; beim Weibchen sind die Fühler stärker gebräunt. Behaarung doppelt, sehr kurz, kaum aufstehend und ziemlich dicht, lang abstehend. Länge, 3 bis 4 Millimeter.

MINDANAO, Dapitan (*Baker*), ein Pärchen.

Rhynchites griseipilosus sp. nov.

Kopf fein und nicht dicht punktiert, eine seichte Abschnürung ist festzustellen. Augen mässig stark vorgewölbt. Rüssel so lang wie das Halsschild, kräftig, plump, schwach gebogen; auf der Basalhälfte nur stumpf gekielt, im übrigen kräftig und dicht punktiert. Fühler beim Männchen etwas vor, beim Weibchen in der Rüsselmitte eingefügt. Männchen: Schaftglied sehr kurz, kaum so lang wie breit; das erste Geisselglied gut doppelt so lang wie das Schaftglied; das zweite Geisselglied verkehrt kegelförmig und so lang wie das erste Glied; das dritte bis fünfte Glied kürzer; das sechste Glied deutlich länger als breit; das siebente Glied stärker rundlich. Das erste Glied der Keule wenig länger als breit; das zweite Glied so lang wie breit; das dritte Glied schwächer und zugespitzt. Weibchen: Schaft- und erstes Geisselglied gleichlang, länger als breit; das zweite Glied wenig länger als das erste; das dritte und vierte Glied so lang wie das erste Glied. Halsschild etwas breiter als lang, seitlich schwach gerundet, am Vorderrand viel schmaler als an der Basis; wenig kräftig und dicht punktiert. Flügeldecken gut ein-und-ein viertelmal so lang wie breit, seitlich parallel. Punktstreifen mässig stark, Zwischenräume etwas breiter als die Streifen, sehr dicht unregelmässig punktiert. Der verkürzte Seitenstreifen vereinigt sich mit dem Randstreifen in der Mitte der Decken. Vordertibien schmaler und länger als die Mittel- und Hintertibien.

Färbung schwarz, Oberseite bläulich; Kopf bei einem Exemplar erzglänzend. Behaarung der Oberseite dicht greis und lang abstehend. Unterseite mit Ausnahme des weniger dicht behaarten Abdomens dicht anliegend greis behaart, die Behaarung den Untergrund verdeckend. Länge, 3.5 bis 3.8 Millimeter.

BORNEO, Sandakan (*Baker 13934*), ein Pärchen.

Subgenus **Auletomorphus** novum

Rhynchites isabellinus sp. nov.

Kopf breiter als lang; glatt, glänzend, mit feinen zerstreuten Punkten besetzt; jeder Punkt trägt ein senkrecht aufstehendes Härchen. Augen vorgewölbt. Rüssel schwach gebogen, an der Spitze etwas verbreitert; beim Männchen ein wenig länger als Kopf und Halsschild zusammen, beim Weibchen erheblich

länger; im übrigen walzenrund, glänzend, ziemlich fein, teilweise reihig punktiert. Fühler im basalen Viertel bis Fünftel eingelenkt; Rüssel hier schwach knotig verdickt und doppelt gefurcht. Schaftglied keulenförmig und etwas länger als das erste Geisselglied; das zweite bis vierte Glied gleichlang und ein wenig kürzer als das erste Glied; das fünfte Glied wiederum etwas kürzer und wohl zweimal so lang wie breit; das sechste und siebente Glied kräftig, jedoch noch länger als breit. Keule lose gegliedert, die einzelnen Glieder spindelförmig und etwa dreimal so lang wie breit. Halsschild kaum kürzer als breit, glänzend, manchmal fein quergerunzelt und fein zerstreut punktiert. Seitlich gleichmässig gerundet, zur Spitze schwach verengt und hier etwas kräftiger ringförmig eingeschnürt als vor der Basis. Auf der Scheibe befindet sich ein linienförmiger Längsriss. Basalkante nicht ganz grade abgeschnitten, sondern zum Schildchen etwas vorgezogen. Flügeldecken wohl anderthalbmal so lang wie breit; seitlich parallel; Schulterbeule wenig ausgeprägt. Punktstreifen kräftig, Punkte nicht isoliert stehend. Zwischenräume breiter als die Punktstreifen und fein punktiert. Schenkel oben mit sehr feinen, schwarzen Höckerchen reihig besetzt; Klauen gespalten.

Behaarung gelblich greis, ziemlich lang abstehend. Färbung rötlich gelb. Rüssel (mit Ausnahme der Basis) und Fühler (mit Ausnahme manchmal der Spitzen der Geisselglieder) schwarzbraun bis schwarz, Tibien und Tarsen teilweise gebräunt. Länge, 5.5 Millimeter.

LUZON, Provinz Laguna, Los Baños; Mount Maquiling (*Baker 2464*), 2 Männchen, 1 Weibchen.

Rhynchites latiusculus sp. nov.

Kopf quer, ziemlich fein und entfernt stehend punktiert; Schläfen länger als die Augen, gerundet. Augen ziemlich klein und kräftig vorgewölbt, von der Seite gesehen treten sie etwas über den Kopf nach oben hinaus. Rüssel lang und schlank, länger als Kopf und Halsschild zusammen, schwach gebogen, rund; an der Basis mit zwei Längsfurchen, kräftigem Mittelkiel, und schwächeren Seitenkielen versehen; im übrigen glänzend, fein längspunktiert. Fühler hinter der Rüsselmitte eingelenkt, doch nicht ganz im basalen Drittel. Schaftglied schlank, verkehrt kegelförmig, so lang wie der Rüssel an der Einlenkungsstelle. Das erste Geisselglied länglich oval, halb so lang wie das Schaftglied; das zweite Glied wenig länger als das erste; das dritte bis fünfte Glied gleichlang, fast anderthalbmal so lang wie das

erste Glied; das sechste Glied kaum länger als das zweite Glied; das siebente Glied so lang wie das erste. Keule kräftig, das mittlere Glied etwas länger als die einschliessenden. Halsschild etwas breiter als lang, nicht stark und wenig dicht, lediglich vor der Basis kräftiger und dichter punktiert. Seitlich mässig stark gerundet, hinter der Mitte am breitesten, an der Basis fein gerundet, und vor dem Vorderrand etwas eingezogen. Flügeldecken nicht ganz doppelt so lang wie breit, seitlich parallel. Punkte der Streifen mässig stark und dicht. Zwischenräume etwas breiter als die Punktstreifen, schwach gewölbt, und sehr fein punktiert.

Färbung rötlich braun; Spitzenhälfte des Rüssels schwarz, Keule geschwärzt. Behaarung der Decken fein, kurz, und fast anliegend, des Halsschilds und Kopfes aufgerichtet, namentlich auf dem Kopf auch länger. Unterseite spärlich behaart. Länge, 5 Millimeter.

MINDANAO, Zamboanga (*Baker*), 1 Exemplar.

Rhynchites gracilirostris sp. nov.

Kopf quer, gewölbt, glänzend; nur sehr fein und zerstreut punktiert; Stirn zwischen den Augen doppelt so breit wie der Rüssel. Augen klein, ziemlich kräftig vorgewölbt. Stirn zum Rüssel abfallend, und auch die Augen der Unterseite des Kopfes stark genähert. Rüssel lang und schlank, gleichmässig gebogen, länger als Kopf und Halsschild zusammen, glänzend, vor der Basis fein gekielt, an der Spitze mässig verbreitert. Fühlerfurche nur sehr kurz, kaum so lang wie das Schaftglied. Fühler im basalen Drittel eingelenkt, sehr schlank. Schaftglied lang, länger als der Rüssel stark; das erste Geisselglied viel kürzer, kaum die Hälfte der Länge des Schaftglieds, fast dreimal so lang wie breit; das zweite Geisselglied wie die nachfolgenden verkehrt kegelförmig, so lang wie das erste; das dritte Glied fast so lang wie das Schaftglied; das vierte und fünfte Glied gleichlang, kürzer als das dritte Glied und länger als das erste und zweite Glied; das sechste und siebente Glied etwas kräftiger, ersteres so lang wie das erste Geisselglied, letzteres ein wenig kürzer, aber doppelt so lang wie breit. Keule kräftig, verhältnissmässig gedrungen, die Glieder ungefähr gleichlang, länger als breit. Halsschild breiter als lang, seitlich schwach gerundet, zum Vorderrand etwas mehr als zur Basis verschmälert, an letzterer fein gerandet. Punktierung wenig kräftig, verrunzelt. Scheibe mit feiner Mittellinie. Flügeldecken anderthalbmal so lang wie breit, parallelseitig. Punktstreifen

mässig kräftig, Zwischenräume viel breiter und dicht unregelmässig punktiert.

Färbung rotgelb. Rüssel und Fühler, der grösste, hintere Teil der Flügeldecken schwarz, auch die Spitze der Tibien und Tarsen mehr oder weniger geschwärzt. Behaarung gelblich, anliegend, dazwischen stehen weniger lange Haare senkreckt auf. Länge, 3.6 Millimeter.

BORNEO, Sandakan (*Baker*), 1 Exemplar.

Rhynchites cupido Pascoe.

PENANG (*Baker*), 1 Exemplar.

Rhynchites pilifer sp. nov.

Kopf breiter als lang, glänzend, unpunktiert. Augen klein und weniger kräftig vorgewölbt. Stirn zwischen den Augen mehr als doppelt so breit wie der Rüssel; Kopf vor den Augen konisch zum Rüssel verschmälert. Rüssel lang, viel länger als Kopf und Halsschild zusammen, wenig und gleichmässig gebogen; walzenrund, kurz vor der Spitze verbreitert; schwach glänzend, wenig deutlich punktiert. Basis schwach gekielt und seitlich jederseits mit am Grunde mattierten, seichten Furchen versehen. Fühler kurz vor der Basis eingelenkt. Fühlerfurchen sehr flach und kurz. Schaftglied lang, schwach keulenförmig, so lang wie der Rüssel an der Einlenkungsstelle dick. Das erste Geisselglied fast so lang wie das Schaftglied; das zweite Glied erheblich kürzer; das dritte bis fünfte Glied gleichlang, wenig kürzer als das zweite Glied; das sechste Glied wiederum etwas kürzer; das siebente Glied noch deutlich länger als breit. Keule kräftig, die Glieder gleichlang und jedes so lang wie die zwei letzten Geisselglieder zusammen. Halsschild breiter als lang, seitlich ziemlich gleichmässig gerundet; am Vorderrand etwas schmaler als an der seicht eingeschnürten und fein gerandeten Basis. Punktierung in etwas entfernt stehende Risse verlaufend. Flügeldecken nicht ganz anderthalb mal so lang wie breit, parallelseitig. Punktfurchen mässig stark. Zwischenräume gewölbt und kaum breiter als die Streifen, dicht punktiert.

Färbung dunkelbraun; Oberseite mit Purpurglanz. Behaarung greis, schuppenförmig, anliegend. Die Haare sind schwach gebogen und auf den Decken reihig geordnet. Auf der Unterseite sind die Epimeren der Mittelbrust und das Epistom der Hinterbrust dicht anliegend abstechend behaart. Länge, 6.2 Millimeter.

MINDANAO, Provinz Agusan, Butuan (*Baker*), 1 Exemplar.

Rhynchites infuscatus sp. nov.

Kopf breiter als lang, glänzend; sehr fein und wenig dicht punktiert. Augen mässig gross und ziemlich kräftig vorgewölbt. Rüssel so lang wie Kopf und Halsschild zusammen; grade, walzenrund, von der Basis zur Mitte sich verengend, und zur Spitze in gleicherweise sich wieder erweiternd; schwach glänzend, fein punktiert, an der Basis mit Mittelkiel. Fühler im basalen Viertel eingelenkt. Schaftglied halb so lang wie der Rüssel an der Einlenkungsstelle dick. Das erste Geisselglied länglich oval und etwas kürzer als das Schaftglied; das zweite Glied wie die Nächsten verkehrt kegelförmig, etwas kürzer als das erste; das dritte und vierte Glied so lang wie das erste; das fünfte und sechste Glied so lang wie das zweite Glied; das siebente Glied so lang wie breit; die letzten Glieder breiter als die ersten. Keule kräftig, das erste Glied derselben fast so lang wie die letzten drei Geisselglieder zusammen; das zweite Glied wenig, das dritte Glied etwas stärker gegenüber dem ersten verkürzt. Halsschild so lang wie breit, seitlich schwach und ziemlich gleichmässig gerundet; an der Basis etwas breiter als am Vorderrand, hier wie dort sehr seicht eingeschnürt. Punktierung fein, wenig dicht; in der Mitte querrunzlig. Flügeldecken nicht ganz anderthalbmal so lang wie breit; seitlich parallel. Punktfurchen ziemlich kräftig, Punkte jedoch nicht zusammenlaufend; Zwischenräume gewölbt, so breit wie die Streifen, dicht und fein punktiert. Mittel- und Hintertibien gedrungen, Vordertibien schlanker.

Färbung dunkel rotbraun; Basis der Schenkel, weniger die Tibien und Tarsen etwas aufgehellt. Behaarung dünn, gelblich, anliegend; zwischendurch mit aufstehenden Haaren besetzt. Auf der Unterseite sind die ganzen Epimeren der Mittelbrust, Basis der Hinterbrust, und das Epistom abstechend weiss behaart. Länge, 4.8 Millimeter.

BORNEO, Sandakan (*Baker*), 1 Exemplar.

Rhynchites pectoralis sp. nov.

Kopf breiter als lang, glänzend; äusserst fein und wenig dicht punktiert. Augen klein, kräftig vorgewölbt; Schläfen seitlich gleichmässig gerundet, fast so lang wie der Augenlängsdurchmesser. Rüssel kräftig, grade, etwas länger als Kopf und Halsschild zusammen, zur Spitze wenig und allmählich verbreitert, im übrigen walzenrund; an der Basis besteht Neigung zur Kielbildung. Punktierung nur sehr fein, zerstreut; zur

Basis etwas kräftiger und dichter. Fühler unweit der Basis eingelenkt; Fühlerfurche sehr kurz und flach. Schaftglied kräftiger als die nächsten Glieder, keulenförmig, etwa dreimal so lang wie breit; das erste bis vierte Geisselglied gleichlang, etwas kürzer als das Schaftglied; das erste Glied länglich oval, die nachfolgenden verkehrt kegelförmig; das fünfte und sechste Glied etwas kürzer, untereinander von gleicher Länge; das siebente Glied noch etwas länger als breit. Keule kräftig, das erste Glied nicht ganz so lang wie die letzten drei Geisselglieder; das zweite Glied etwas kürzer; das dritte Glied am kürzesten. Halsschild breiter als lang, seitlich gerundet, und hinter der Mitte am breitesten, von dort zum Vorderrand ziemlich kräftig verengt; Basis schwach eingeschnürt, Vorderrand nur undeutlich. Punktierung sehr fein und dicht. Auf der Scheibe vor der Basis mit leichtem Eindruck. Flügeldecken länger als breit; seitlich fast parallel, hinter den Schultern leicht eingezogen. Punktstreifen sehr stark und tief; Zwischenräume gewölbt und so breit wie die Streifen, fein und dicht punktiert. Vorletzter Streifen vereinigt sich wie bei den vorhergehenden Arten in der Mitte der Decken. Tibien schlank; Mitteltibien schwach einwärts gebogen.

Färbung rot; Rüsselspitze gebräunt. Behaarung der Oberseite kurz, anliegend. Auf der Unterseite sind die Epimeren der Mittel- und Hinterbrust dicht anliegend greis behaart. Im übrigen its die Unterseite einschliesslich der Beine nur äusserst fein anliegend behaart. Länge, 7.5 Millimeter.

BORNEO, Sandakan (*Baker*), 1 Exemplar.

Subgenus **Piazorhynchites** novum

Rhynchites pedestris sp. nov.

Kopf etwas breiter als lang, fein und dicht punktiert. Augen kräftig gewölbt. Stirn zwischen den Augen etwas breiter als der Rüssel vor der Basis. Rüssel so lang wie Kopf und Halsschild zusammen, fast grade, walzenrund, vor der Basis schwach gekielt; fein und wenig dicht punktiert, schwach glänzend. Fühler kurz vor der Basis eingelenkt. Fühlerfurche kurz, länglich. Schaftglied etwa halb so lang wie der Rüssel an der Einlenkungsstelle dick; das erste Geisselglied so lang wie das Schaftglied; das zweite Glied kürzer; das dritte und vierte Glied so lang wie das erste; das fünfte Glied so lang wie das zweite; das sechste und siebente Glied etwas kürzer, doch noch länger als breit. Keule kräftig; das erste Glied etwas länger als die zwei letzten Geisselglieder;

das zweite Glied etwas kürzer; das dritte Glied wiederum kürzer und erheblich schwächer. Halsschild so lang wie breit, seitlich mässig gerundet, die grösste Breite liegt etwas hinter der Mitte; zum Vorderrand etwas mehr verengt als zur Basis. Punktierung mässig kräftig, querrunzlig. Flügeldecken fast doppelt so lang wie breit, seitlich parallel, oben wenig gewölbt. Punktstreifen kräftig, Punkte schmal getrennt. Zwischenräume hinten breiter als die Streifen, zur Basis hin sehr schmal. Tibien gedrungen und sehr stark zur Spitze verbreitert. Hintere Tibien aussen mit kräftigem, breitem, an der Spitze abgerundetem Fortsatz versehen.

Färbung dunkelbraun; Fühler rotbraun, Pygidium gelbrot. Behaarung kräftig, gelb, anliegend; auf den Decken ziemlich regelmässig fleckig verteilt, in den Flecken bis auf die der Naht quer gestellt. Unterseite, besonders die Seitenteile der Mittel- und Hinterbrust dichter gelb behaart. Länge, 6.6 Millimeter.

BORNEO, Sandakan (*Baker 12911*), 1 Exemplar.

Subgenus **Involvulus** Seidlitz

Rhynchites spadiceus sp. nov.

Kopf breiter als lang, glänzend, mit feinen zerstreuten Punkten besetzt, in welchen sich je ein schwarzes, aufstehendes Härchen befindet. Die Stirn trägt eine flache Grube. Rüssel schlank, gebogen; beim Männchen so lang wie Kopf und Halsschild zusammen, beim Weibchen länger. An der Basis stumpf gekielt und beiderseits schwach gefurcht, an der Fühlereinlenkungsstelle schwach knotig verstärkt, und auf dem Rücken mit einer Längsgrube versehen; glänzend und nur fein punktiert. Fühlerschaft etwa so lang wie das erste und zweite Geisselglied zusammen. Geisselglieder auffallend schlank und lang gestreckt. Halsschild so lang wie breit, zur Spitze schwach gerundet verengt, fein und zerstreut punktiert, glänzend und mehr oder weniger flach runzlig. Flügeldecken länger als breit, nach hinten zu kaum merklich verschmälert. Punktstreifen ziemlich kräftig, die Punkte stehen um die Grösse ihres Durchmessers oder mehr von einander isoliert; auch die Zwischenräume breiter als die Streifen, fein und dicht unregelmässig punktiert. Ein Skutellarstreifen fehlt (wie bei allen *Involvulus*-Arten).

Färbung rotgelb bis bräunlich; Rüssel, die letzten Geisselglieder, und die Keule, manchmal auch die stets angedunkelten Tarsen und teilweise die Schienen schwarz. Behaarung fein, gelblich, fast anliegend; auf den Flügeldecken mehr oder weniger

quer gelagert; dazwischen längere aufstehende Haare. Länge, 4 bis 5 Millimeter.

LUZON, Mount Banahao (*Baker*), 1 Männchen, 2 Weibchen. PALAWAN, Puerto Princesa (*Baker 5940*).

Rhynchites antennalis sp. nov.

Kopf quer, hinter den Augen undeutlich eingeschnürt, fein und entfernt stehend punktiert. Augen kräftig vorgewölbt, der Längsdurchmesser etwas grösser als der Rüssel vor der Basis; Stirn kaum so breit wie der Rüssel, seicht längsgefurcht. Rüssel fast so lang wie Kopf und Halsschild zusammen, leicht gebogen; auf der Basalhälfte mit Mittelkiel, seitlich gefurcht, vorn glatt und nur schwach längspunktiert, auch hier an den Seiten gefurcht. Fühler wenig hinter der Mitte des Rüssels eingelenkt; das erste Geisselglied mehr als doppelt so lang wie breit und etwas länger als das Schaftglied; das zweite bis vierte Glied gleichlang, kaum kürzer als das Schaftglied; das fünfte Glied länger als breit; das sechste und siebente Glied so lang wie breit. Keule sehr lang und kräftig, länger als die Geissel; das erste und zweite Glied gleichlang, das dritte Glied erheblich kürzer. Halsschild so lang wie breit, seitlich schwach gerundet, nach vorn mehr verschmälert als zur Basis. Punktierung fein und zerstreut. Flügeldecken nicht ganz anderthalbmal so lang wie breit, fast parallelseitig, hinten wenig breiter als an der Basis, hinter dem Schildchen eingedrückt. Punktstreifen mässig stark, Zwischenräume breiter als die Streifen, einreihig punktiert. Die Seiten der Hinterbrust, des Halsschilds, sowie die Seitenteile der Hinterbrust kräftig und dicht punktiert. Abdomen nur sehr fein, undeutlich punktiert.

Färbung rötlichbraun; Rüsselspitze und Keule schwarz. Behaarung doppelt; sehr lang, abstehend und kürzer, geneigt; gelblich. Länge, 2.8 Millimeter.

BORNEO, Sandakan (*Baker 13945*), 1 Tier.

Rhynchites nigriclavatus sp. nov.

Kopf quer; mässig stark und sehr dicht punktiert. Augen kräftig vorgewölbt. Rüssel kaum so lang wie Kopf und Halsschild zusammen, kräftig, wenig gebogen; Basis mit schwachem Mittelkiel; die Seiten ziemlich kräftig und dicht reihig punktiert, im übrigen etwas rauh skulptiert. Fühler hinter der Rüsselmitte eingelenkt; Schaftglied etwa halb so lang wie der Rüssel an der Einlenkungsstelle dick; das erste Geisselglied so stark und so lang wie das Schaftglied, länglich oval, fast walzenförmig.

Die nächsten Geisselglieder verkehrt kegelförmig, die drei letzten erheblich kräftiger als die voraufgehenden Glieder; das zweite bis vierte Glied so lang wie das erste Geisselglied; die nächsten an Länge allmählich abnehmend, das siebente Glied kaum länger als breit. Keule sehr kräftig, die beiden ersten Glieder dreieckig, viel länger als breit; das letzte Glied etwas kürzer als 1 und 2. Halsschild etwa so lang wie breit, fein und nicht ganz dicht punktiert. Seitlich mässig gerundet, hinter der Mitte am breitesten; Basis fein gerandet. Flügeldecken gut anderthalbmal so lang wie breit, seitlich parallel. Punktstreifen lediglich zur Basis hin kräftiger, hinten fast erloschen. Zwischenräume breit, viel breiter als die Streifen. Der vorletzte Punktstreifen vereinigt sich mit dem Randstreifen vor der Mitte der Decken, in der Höhe der Hinterhüften; er ist fast grade, kaum geschweift. Zwischenräume nur sehr fein punktiert. Das Pygidium ist bei dem einzigen mir vorliegenden Tier fast von den Decken bedeckt, ohne dass sich jedoch feststellen lässt ob dieser Umstand von grundlegender Bedeuting ist.

Färbung rotgelb; Rüsselspitze, Keule, und die beiden letzten Geisselglieder schwarz. Behaarung der Decken fast anliegend, gelblich; dazwischen mit länger aufstehenden Haaren durchsetzt. Unterseite sparsam anliegend behaart. Länge, 3.6 Millimeter.

BORNEO, Sandakan (*Baker*), 1 Stück.

Rhynchites pallidipennis sp. nov.

Kopf quer, fein und zerstreut punktiert. Augen ziemlich gross und mässig vorgewölbt. Rüssel etwas länger als Kopf und Halsschild zusammen, vor der Basis mit kräftigem Mittelkiel, seitlich desselben schwach gefurcht; auf der Spitzenhälfte fein und dicht punktiert, an der Spitze verbreitert. Fühler kurz hinter der Mitte unter einer Verstärkung des Rüssels eingelenkt. Schaftglied halb so lang wie der Rüssel an der Einlenkungsstelle dick ist, etwa doppelt so lang wie breit; das erste bis vierte Geisselglied so lang wie das Schaftglied, das erste länglich oval, die übrigen verkehrt kegelförmig; das fünfte Glied unerheblich kürzer; das sechste Glied kräftiger und etwas kürzer als das fünfte Glied; das siebente Glied so lang wie breit. Keule kräftig, Glied 1 und 2 so lang wie breit, ersteres aber etwas kräftiger. Halsschild so lang wie breit, seitlich gleichmässig gerundet, am Vorderrand kaum schmaler als an der Basis, an ersterem etwas eingezogen, an letzterem fein gerandet. Punktierung fein und dicht runzlig. Flügeldecken anderthalb-

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mal so lang wie breit. Punktstreifen mässig stark, Punkte nicht dicht. Zwischenräume sehr schmal, teilweise schwach rippenförmig erscheinend. Zwischen den Punkten der Streifen befinden sich noch feinere, dicht angeordnete Punkte. Abdomen sehr fein und zerstreut punktiert.

Färbung rötlich gelb; Spitzenhälfte des Rüssels, die Fühler, Tibien, und Tarsen schwarz. Behaarung kurz und wenig aufgerichtet, mit einzelnen aufstehenden längeren Haaren untermischt. Unterseite spärlich behaart. Länge, 4 Millimeter.

BASILAN (*Baker*), 1 Tier.

Rhynchites pectitus sp. nov.

Kopf fein und nicht dicht punktiert. Augen beim Weibchen wenig, beim Männchen mehr vorgewölbt. Stirn des Weibchens viel breiter als der Rüssel an seiner schmalsten Stelle (bei *R. balneator,* dem diese Art sehr nahe steht, weniger breit). Rüssel länger als Kopf und Halsschild zusammen, beim Männchen etwas kürzer, kräftiger, und kaum gebogen, beim Weibchen mehr gebogen. Basalhälfte gekielt und beiderseits längsgefurcht; Spitzenhälfte längsfurchig punktiert. Fühler kurz hinter der Rüsselmitte eingelenkt. Weibchen: Schaft- und erstes Geisselglied gleichlang, dreimal so lang wie breit; das zweite Glied etwas länger als das erste; das dritte und vierte Glied kaum kürzer als das zweite Glied; das fünfte Glied kürzer als das vierte und kaum länger als das sechste; das siebente Glied noch länger als breit. Keule mässig kräftig, das erste Glied etwas länger als das zweite Glied, auch das letzte etwas länger als das zweite, letzteres aber noch länger als breit. Halsschild länger als breit, seitlich fast parallel, sehr fein und ziemlich dicht punktiert; auf der Mitte der Scheibe ist nur eine feine Mittelfurche angedeutet. Flügeldecken parallelseitig, gut anderthalbmal so lang wie breit. Punktfurchen weniger kräftig, flach; Zwischenräume schmaler als die Streifen, dicht und sehr fein punktiert. Der verkürzte Seitenstreifen vereinigt sich mit dem Randstreifen hinter der Mitte der Decken.

Färbung gelblich braun; Keule mit der Geissel gleichfarbig. Behaarung goldgelb, anliegend, untermischt mit kurzen, aufstehenden Härchen. Auf den Decken und dem Halsschild ist die Behaarung von der Mitte nach den Seiten quergekämmt. Länge, 3 bis 3.2 Millimeter.

LUZON, Provinz Mountain, Baguio (*Baker*), 1 Männchen. MINDANAO, Dapitan (*Baker*), 1 Weibchen.

Durch die goldgelbe seitwärts gerichtete Behaarung, feiner punktiertes Halsschild, nicht geschwärzter Naht, etc., von dem am nächsten stehenden *R. balneator* leicht zu trennen.

Rhynchites weberi sp. nov.

Kopf nicht ganz so lang wie breit; Augen nur mässig stark vorgewölbt, mässig kräftig und dicht punktiert. Rüssel des Männchens etwa so lang wie Kopf und Halsschild zusammen, der des Weibchens deutlich länger; schwach gebogen, Basalhälfte bis zur Fühlereinlenkung gekielt und beiderseits punktiert gefurcht; Apikalhälfte kräftig längsrunzlig punktiert. Fühler kurz hinter der Mitte des Rüssels eingelenkt. Schaft- und das erste bis fünfte Geisselglied gleichlang, gestreckt; Schaft- und erstes Geisselglied länglich oval, die übrigen verkehrt kegelförmig; Endglied zugespitzt und vom dritten nicht deutlich getrennt. Halsschild kaum kürzer als breit, seitlich zum Vorderrand schwach gerundet verengt, an der Basis nicht merklich eingezogen; mässig stark runzlig punktiert und mit fein angedeuteter Mittelfurche versehen. Flügeldecken länger als breit, parallel; Punktstreifen ziemlich kräftig, Punkte stehen isoliert und um mehr als ihren Durchmesser von einander entfernt; Zwischenräume breit, wohl dreimal so breit wie die Punkte gross sind. Sie sind zwei- bis dreireihig fein punktiert.

Färbung rotgelb; Rüssel schwarzbraun, Fühler schwarz; Tarsen angedunkelt; Seiten, Spitze, sowie die Naht der Decken schwarzbraun gefärbt. Behaarung auf Kopf, Halsschild, und Flügeldecken von zweifacher Art; eine kurze, gelblichgreise halbaufstehende untermischt mit längeren senkrecht abstehenden dunklen Porenhaaren, von denen eine Reihe in je einem Punkt stehend auch auf der Unterseite des Halsschildes, entlang dem Vorderrand angeordnet ist. Länge, 3.5 Millimeter.

MINDORO, Mangaren (*Bureau of Science 13431, 13443 C. M. Weber*), 4 Exemplare.

Rhynchites balneator sp. nov.

Diese Art steht der vorigen sehr nahe und unterscheidet sich von derselben im wesentlichen folgendermassen:

Die Skulptur der Flügeldecken ist eine andere. Zwischenräume kräftig gewölbt und kaum so breit wie die Punktstreifen. Die feinere Punktierung auf den Zwischenräumen ist verrunzelt und unscharf. Die Punkte der Streifen stehen nicht isoliert wie bei *R. weberi*, sie sind kräftiger und gehen in einander über.

Die feinere Behaarung ist anliegender und hinten auf der Spitzenhälfte der Flügeldecken scheitelartig quergelagert. Die mittleren Geisselglieder sind rotgelb gefärbt, die dunklere Färbung, die zum Teil auch auf die Unterseite sich erstreckt, während sie auf den Flügeldecken mehr zurücktritt, ist leicht erzglänzend. Auch das Schildchen ist bei dieser Art dunkelbraun gefärbt. Länge, 2.8 bis 3.5 Millimeter.

LUZON, Provinz Laguna, Los Baños, Mount Maquiling: Provinz Mountain, Baguio (*Baker 604, 5935*), 10 Exemplare.

Rhynchites helleri sp. nov.

Kopf quer, ziemlich kräftig und dicht punktiert. Augen mässig stark vorgewölbt, beim Weibchen der Längsdurchmesser etwas kleiner, beim Männchen grosser als der Rüssel vor der Basis. Beim Männchen ist er auf der Basalhälfte fast parallelseitig, beim Weibchen stärker zur Fühlereinlenkung verschmälert. Die Basalhälfte trägt einen Mittelkiel, der seitlich beiderseits von einer kräftigen Punktfurche begrenzt wird. Spitzenhälfte glatt und vereinzelt punktiert. Fühler wenig hinter der Rüsselmitte eingelenkt. Weibchen: Schaftglied ziemlich lang und gestreckt, länger als das erste Geisselglied; das zweite und dritte Glied gleichlang und wenig länger als das Schaftglied; das vierte Glied so lang wie das erste; das fünfte Glied etwas kürzer; das sechste und siebente Glied gleichlang und wiederum etwas kürzer. Keule kräftig und gedrungen; Glied 1 und 2 wenig länger als breit und so lang wie das schwächere dritte. Beim Männchen ist das Schaftglied nicht deutlich länger als das erste Geisselglied. Halsschild etwas länger als breit, seitlich schwach gerundet. Punktierung mässig stark, runzlig; Basis fein gerandet. Flügeldecken annähernd doppelt so lang wie breit, parallelseitig. Punktstreifen mässig kräftig, Zwischenräume so breit wie diese, gewölbt; fein und sehr dicht, etwas runzlig punktiert. Der abgekürzte Seitenstreifen vereinigt sich erst hinter der Mitte der Decken mit dem Randstreifen. Hinterbrust fein und dicht, Seitenteile etwas kräftiger punktiert, Abdomen fein verrunzelt. Vordertibien schlank und grade, Mitteltibien ziemlich kräftig einwärts gebogen. Hintertibien kielförmig zur Spitze verbreitert.

Färbung blau; Fühler, Tarsen, und Rüssel schwarz. Behaarung fein und kurz, wenig aufgerichtet, untermischt mit etwas längeren abstehenden schwarzen Haaren. Länge, 4 bis 5.2 Millimeter.

LUZON, Los Baños, Mount Banahao, Mount Maquiling. MINDANAO, Iligan (*Baker 2463, 935, 1395, 4428*), 7 Exemplare.

Rhynchites plagiocephalus sp. nov.

Kopf quer, mässig kräftig und mehr oder weniger dicht punktiert. Augen mässig vorgewölbt; beim Weibchen der Längsdurchmesser so gross wie der Rüssel vor der Basis dick, beim Männchen viel grösser. Rüssel des Männchens nur so lang wie das Halsschild, des Weibchens so lang wie Kopf und Halsschild zusammen, schwach gebogen. Basalhälfte mit Mittelkiel, seitlich punktiert, längsgefurcht; auch zwischen der Fühlereinlenkung mit länglicher Furche; Spitzenhälfte glatt, zerstreut punktiert. Fühler des Männchens in der Mitte, des Weibchens hinter der Mitte des Rüssels eingelenkt. Männchen: Schaft- und erstes bis drittes Geisselglied gleichlang, doch ist das Schaft- und das erste Geisselglied länglich oval und kräftiger als die übrigen verkehrt kegelförmigen Glieder; das vierte bis sechste Glied etwas kürzer, das siebente Glied noch länger als breit. Keule ziemlich schlank; das erste und zweite Glied gleichlang und jedes fast so lang wie die drei letzten Geisselglieder zusammen; das dritte Glied kürzer. Weibchen: Das zweite Geisselglied länger als das erste Glied; das vierte und fünfte Glied wenig länger als das sechste Glied. Halsschild länger als breit, seitlich schwach gerundet, zum Vorderrand mehr als zur Basis verschmälert; runzlig punktiert. Basis fein gerandet. Flügeldecken parallelseitig, gut anderthalbmal so lang wie breit. Punktstreifen mässig kräftig; Zwischenräume so breit wie diese, gewölbt und dicht, fein, schwach runzlig punktiert. Der verkürzte Seitenstreifen verbindet sich mit dem Randstreifen in der Höhe der Hinterhüften.

Färbung schwarz, Schenkel an der Basis hellgelb. Behaarung kurz, anliegend, dünn, mit einzelnen aufstehenden Härchen untermischt. Länge, 2.5 bis 3.5 Millimeter.

LUZON, Mount Maquiling: Nueva Vizcaya, Imugan: Benguet, Baguio. MINDANAO, Davao, Dapitan, Kolambugan. (*Baker 8388, 8392, 8393, 8389, 8381, 8390.*) LUZON, Isabela, Iligan (*Bureau of Science 9783 H. E. Stevens*) : San Luis (*Bureau of Science 15467 C. R. Jones*).

Diese Art scheint recht variabel zu sein. Die Punktierung des Kopfes weicht ab, sie kann fein und zerstreut und kräftiger sehr dicht sein. Die Färbung der Schenkelbasis kann sich auf die ganzen Schenkel, Tibien, und Hüften erstrecken: forma nova *pallidipes*. Häufig ist das Abdomen rotbraun, bisweilen die

Unterseite des Kopfes und das ganze Halsschild: forma nova *rubricollaris*. Diese Form liegt mir namentlich von Palawan (*Boettcher* leg.) zahlreich vor. Bisweilen haben die Decken Bleiglanz, manchmal bläulichen und zuweilen erzfarbenen Schein.

Rhynchites sandakanensis sp. nov.

Kopf quer, fein und nicht ganz dicht punktiert. Augen ziemlich kräftig vorgewölbt, ihr Längsdurchmesser wenig kleiner als die Stirn breit und diese breiter als der Rüssel vor der Basis. Rüssel länger als Kopf und Halsschild zusammen, seicht gebogen. Basalhälfte mit Mittelkiel, der beiderseits von einer Längsfurche begrenzt wird; vorn glänzend und länglich punktiert. Fühler hinter der Rüsselmitte eingelenkt. Schaft- und die beiden ersten Geisselglieder gleichlang, gestreckt; das dritte und vierte Glied etwas kürzer; das siebente Glied noch etwas länger als breit. Glieder der Keule viel länger als breit, untereinander gleichlang. Halsschild so lang wie breit, ziemlich fein, runzlig punktiert; seitlich schwach und gleichmässig gerundet, am Vorderrand kaum schmaler als an der Basis. Flügeldecken anderthalbmal so lang wie breit, parallelseitig. Punktstreifen vorn kräftig, hinten feiner werdend; Zwischenräume hinten so breit wie die Streifen, fein und dicht punktiert. Der verkürzte Seitenstreifen verbindet sich mit dem Randstreifen in der Mitte der Decken.

Färbung schwarz; Kopf, Halsschild, und Abdomen rot; die Basis der Mittel- und Hinterschenkel, die Vorderschenkel unterseits gelb gefärbt. Behaarung gelblich, auf den Decken kurz anliegend untermischt mit längeren aufstehenden Härchen. Länge, 3.5 Millimeter.

BORNEO, Sandakan (*Baker*), 1 Exemplar.

Rhynchites furtivus sp. nov.

Kopf mässig stark und dicht punktiert; Augen mässig vorgewölbt, Stirn so breit wie der Rüssel vor der Basis. Rüssel kaum so lang wie Kopf und Halsschild zusammen, seicht gebogen; Basis mit schwachem Mittelkiel, im übrigen ziemlich kräftig punktiert, auf der Spitzenhälfte glatt. Fühler hinter der Rüsselmitte eingelenkt. Schaft- und erstes Geisselglied gleichlang, länger als breit; das zweite bis vierte Glied so lang wie das erste, das dritte Glied wenig kürzer; das fünfte bis siebente Glied noch deutlich länger als breit. Das erste Glied der Keule so lang wie breit, das zweite Glied quer. Halsschild breiter als lang, mässig stark und ziemlich dicht punktiert, eine schmale Längsfläche der Scheibe glänzend und punktfrei. Seitlich schwach

gerundet, konisch zum Vorderrand verschmälert. Flügeldecken parallelseitig, ein-und-ein-viertelmal so lang wie breit. Punktfurchen mässig kräftig, Zwischenräume etwas breiter als die Streifen, schwach gewölbt, sehr fein und nicht dicht punktiert.

Färbung schwarz mit Bleiglanz. Behaarung fast anliegend, ziemlich dicht. Die Brust mit Seitenteilen dichter anliegend weiss behaart, Abdomen etwas weniger dicht. Länge, 3 Millimeter.

LUZON, Provinz Laguna, Los Baños (*Baker*). BASILAN (*Baker*), 2 Tiere.

Rhynchites rugiceps sp. nov.

Kopf runzlig punktiert. Augen kräftig vorgewölbt, den Vorderrand des Halsschilds berührend. Augenlängsdurchmesser grösser als der Rüssel vor der Basis breit. Rüssel schlank, gebogen, länger als Kopf und Halsschild zusammen; Basis mit Mittelkiel und beiderseits desselben mit Längsfurche. Spitzenhälfte glänzend und jederseits mit einer Reihe länglicher Punkte besetzt. Fühler hinter der Rüsselmitte fast im basalen Drittel eingelenkt. Schaft- und erstes Geisselglied gleichlang, länglich oval; das zweite und dritte Glied kaum kürzer, die nächsten Glieder etwas kürzer aber länger als breit. Das erste Glied der Keule länger als breit, das zweite Glied so lang wie breit. Halsschild quer, runzlig punktiert, seitlich schwach gerundet, vorn etwas schmaler als an der Basis. Mittelfurche schwach angedeutet. Basis fein gerandet. Flügeldecken länger als breit, parallel, hinter den Schultern schwach eingezogen. Punktstreifen ziemlich kräftig, Zwischenräume wenig breiter, schwach gewölbt, fein punktiert.

Färbung schwarz, Decken mit schwachem Bleiglanz. Behaarung gelb, kurz, und wenig aufgerichtet. Länge, 2.5 Millimeter.

MINDANAO, Dapitan (*Baker*), 1 Exemplar.

Rhynchites foveifrons sp. nov.

Kopf fein und nicht dicht punktiert; Stirn mit Grübchen. Augen mässig stark vorgewölbt, ihr Längsdurchmesser grösser als der Rüssel an der Basis dick. Rüssel des Männchens kaum so lang, des Weibchens länger als Kopf und Rüssel zusammen. Basis mit Mittelkiel, beiderseits desselben mit Längsfurche; Spitzenhälfte ziemlich kräftig punktiert. Fühler beim Männchen in der Mitte, beim Weibchen hinter der Mitte des Rüssels eingelenkt. Schaft- und das erste bis fünfte Geisselglied wenig an Länge verschieden; das siebente Geisselglied noch länger als breit. Glied 1 und 2 der Fühlerkeule so lang wie breit. Hals-

schild so lang wie breit, wenig kräftig runzlig punktiert; seitlich schwach und gleichmässig gerundet, am Vorderrand kaum schmaler als an der Basis; diese fein gerandet. Scheibe mit feiner Mittelfurche. Flügeldecken nicht ganz anderthalbmal so lang wie breit. Punktstreifen sehr kräftig; Zwischenräume schmal und nur vereinzelt punktiert.

Färbung schwarz; Halsschild, Brust, und Unterseite des Kopfes bisweilen mit schwachem Erzschein. Behaarung gelblich, lang abstehend, dazwischen kürzere wenig geneigte Härchen. Länge, 2.5 bis 3 Millimeter.

SINGAPORE (*Baker*), 2 Männchen, 1 Weibchen.

Rhynchites discretus sp. nov.

Kopf quer; fein und zerstreut punktiert. Augen mässig stark vorgewölbt, ihr Längsdurchmesser grösser als der Rüssel vor der Basis. Rüssel fast so lang wie Kopf und Halsschild zusammen, seicht gebogen. Basis mit scharfem Kiel und beiderseits desselben mit Längsfurche. Fühler hinter der Rüsselmitte eingelenkt. Schaft- und erstes Geisselglied gleichlang, mehr als doppelt so lang wie breit; das zweite und dritte Geisselglied kaum kürzer; die nächsten Glieder nehmen zur Keule hin allmählich an Länge ab, das siebente Glied jedoch noch länger als breit. Halsschild kaum so lang wie breit, fein und nicht dicht punktiert; eine leichte Neigung zu runzliger Punktierung besteht. Seitlich schwach gerundet und konisch zum Vorderrand verengt. Flügeldecken kaum anderthalbmal so lang wie breit. Punktstreifen an der Basis kräftig, hinten feiner; Zwischenräume breiter als die Streifen, flach, einzeln fein punktiert.

Färbung schwarz. Behaarung greis, lang abstehend, dazwischen kürzer und schwach geneigt. Seitenteile der Mittel- und Hinterbrust etwas dichter lang anliegend behaart, ohne jedoch den Grund zu verdecken. Länge, 3 Millimeter.

BORNEO, Sandakan (*Baker*), 1 Exemplar.

Rhynchites dissimilicolor sp. nov

Kopf glänzend, fein und zerstreut punktiert. Augen mässig stark vorgewölbt. Rüssel länger als Kopf und Halsschild zusammen, kaum gebogen; Basis mit kräftigem Kiel, beiderseits desselben tief längsgefurcht. Schaft- und erstes Geisselglied gleichlang; das zweite bis vierte Glied kaum länger; das fünfte Glied kürzer; das siebente Glied kaum länger als breit. Halsschild kaum so lang wie breit, glänzend, fein und entfernt stehend

punktiert. Seitlich schwach und gleichmässig gerundet, am Vorderrand kaum schmaler als an der Basis. Flügeldecken anderthalbmal so lang wie breit; seitlich zunächst bis zur Hälfte der Decken parallel, dann stark konisch mit schwacher Rundung zur Spitze verschmälert. Punktstreifen hinter der Basis sehr kräftig, hinten etwas feiner werdend. Während die Zwischenräume vorn sehr schmal sind, werden sie nach hinten so breit wie die Streifen und sind einreihig fein und nicht dicht punktiert.

Färbung schwarz, Flügeldecken schwarzblau glänzend. Behaarung ziemlich lang abstehend, auf den Decken untermischt mit kürzeren, wenig aufgerichteten greisen Härchen. Unterseits mehr anliegend behaart. Länge, 3.5 Millimeter.

BORNEO, Sandakan (*Baker*), 1 Exemplar.

Dem *R. plagiocephalus* sp. nov. ähnlich; durch die Färbung, Punktierung des Halsschildes und der Decken, andere Fühlerbildung, und vor allem durch die Form der Flügeldecken, die bei *R. plagiocephalus* langgestreckt parallel sind, leicht zu trennen.

Rhynchites furvus sp. nov.

Kopf wie das Halsschild runzlig punktiert; Augen wenig vorgewölbt, ihr Längsdurchmesser grösser als die Stirn und der Rüssel an der Basis breit. Letzterer länger als Kopf und Halsschild zusammen, seicht gebogen. Basis wie bei den verwandten Arten mit Mittelkiel und jederseits mit Längsfurche. Spitzenhälfte rauh skulptiert. Fühler wenig hinter der Rüsselmitte eingelenkt; gedrungen gebaut. Schaftglied kaum länger als breit; das erste Geisselglied länglich oval und fast doppelt so lang wie das Schaftglied; das zweite Glied so lang wie das Schaftglied; das dritte und vierte Glied etwas länger; das fünfte und siebente Glied breiter als lang; das sechste Glied so lang wie breit. Halsschild etwas breiter als lang, seitlich schwach gerundet; die grösste Breite liegt kurz vor der Basis; durchaus runzlig punktiert. Flügeldecken länger als breit. Punktstreifen mässig kräftig; Zwischenräume durchaus runzlig. Der verkürzte Seitenstreifen geht hinter der Mitte der Decken in den Randstreifen über.

Färbung tiefschwarz, matt. Behaarung wenig deutlich, kurz, schwarz, und fast anliegend. Länge, 2.5 Millimeter.

BASILAN (*Baker*), 1 Tier.

Dem *R. rugiceps* sp. nov. am nächsten stehend; die runzlige Skulptur erfasst bei dieser Art jedoch auch die Decken und Brust; ausserdem sind die Fühler viel gedrungener gebaut.

Rhynchites pellitus sp. nov.

Kopf ziemlich fein und wenig dicht punktiert; Schläfen parallel. Augen des Weibchens grösser und flacher gewölbt als die des Männchens; der Längsdurchmesser beim Weibchen erheblich, beim Männchen wenig grösser als der Rüssel vor der Basis. Rüssel des Männchens etwas länger als das Halsschild, des Weibchens so lang wie Kopf und Halsschild zusammen; kräftig, seicht gebogen. Fühler in der Mitte des Rüssels eingelenkt. Weibchen: Schaftglied kurz, kaum länger als breit; das erste Geisselglied etwas länger; das zweite Glied so lang wie Schaft- und erstes Geisselglied zusammen; das dritte und vierte Glied gleichlang und etwas kürzer als das zweite Glied; das fünfte und sechste Glied so lang wie das erste; das siebente Glied wenig länger als breit. Das erste und zweite Glied der Keule länger als breit, gleichlang. Männchen: Die Geisselglieder werden vom zweiten Glied zur Keule hin allmählich etwas kürzer, das siebente Glied so lang wie breit, rundlich. Mittleres Keulenglied etwas kürzer als das erste. Halsschild etwas breiter als lang, wenig kräftig und ziemlich dicht punktiert. Die Seiten schwach gerundet, von der Basis zum Vorderrand schwach konisch verschmälert; Basis fein gerandet. Flügeldecken nach hinten etwas gradlinig verbreitert, anderthalbmal so lang wie breit. Punktstreifen mässig kräftig; Zwischenräume breiter als die Streifen, fein und dicht unregelmässig punktiert.

Färbung schwarz, Oberseite bläulich. Behaarung dicht greis, auf der Oberseite gemischt, abstehend und geneigt; ziemlich lang; auf der Unterseite anliegend. Länge, 3.5 bis 5 Millimeter.

LUZON, Los Baños (*Baker 603*), 1 Exemplar: Bataan (*Bureau of Science 9139 W. Schultze*), 20 Juni, 1908.

Rhynchites pilumnus sp. nov.

Kopf ziemlich kräftig und dicht punktiert; Augen gross und mässig kräftig vorgewölbt. Schläfen nach hinten nur undeutlich erweitert, halb so lang wie der Augenlängsdurchmesser. Rüssel ein wenig länger als Kopf und Halsschild zusammen; gleichmässig und kräftig gebogen; Basis mit stumpfem schwachglänzenden Kiel, im übrigen kräftig und dicht längsrunzlig punktiert. Rüsselspitze dreizipfelig ausgezogen, der mittlere Zipfel allerdings nur klein. Fühler vor der Rüsselmitte eingelenkt; Schaft- und erstes Geisselglied gleichlang, länglich oval, zusammen kaum so lang wie der Rüssel an der Einlenkungsstelle dick; das zweite bis vierte Glied etwas länger, untereinander wenig in der Länge verschieden; das fünfte Glied so lang wie das erste;

das sechste und siebente Glied wiederum etwas kürzer, doch noch länger als breit. Keule ziemlich kräftig; das erste und zweite Glied länger als breit. Halsschild so lang wie breit, ziemlich fein und sehr dicht punktiert; seitlich schwach gerundet, die grösste Breite liegt hinter der Mitte; zur Basis wenig, zum Vorderrand mehr verschmälert. Flügeldecken anderthalbmal so lang wie breit, seitlich parallel. Punktstreifen wenig kräftig, Zwischenräume flach und viel breiter als die Streifen.

Färbung grünlich blau, schwach glänzend; Fühler schwarz. Behaarung dünn, greis, anliegend, auf den Decken mit aufstehenden Haaren untermischt; auf dem Halsschild zur Mitte der Scheibe gerichtet. Auch die Unterseite anliegend behaart. Länge, 5.5 Millimeter.

MINDANAO, Iligan (*Baker 13950*), 1 Tier.

Subgenus **Metarhynchites** novum

Rhynchites arduus sp. nov.

Kopf fein und wenig dicht punktiert; Schläfen konisch nach vorn verschmälert und die Augen wenig deutlich aus der Kopfwölbung hervortretend, also nur flach gewölbt; ihr Längsdurchmesser etwas grösser als der Rüssel an der Basis dick. Rüssel des Männchens wenig, des Weibchens viel länger als Kopf und Halsschild zusammen, schwach gebogen; Basis gekielt, zwischen der Fühlereinlenkung mit Längsgrübchen. Neben dem Mittelkiel läuft je eine Längsfurche bis zur Rüsselspitze heran. Im übrigen glänzend und mit reihig angeordneten länglichen Punkten besetzt. Männchen: Schaftglied etwas kürzer als das erste Geisselglied, länglich oval; das zweite bis fünfte Glied gleichlang und etwas kürzer als das erste; das sechste und siebente Glied so lang wie das Schaftglied. Das erste Glied der Keule etwas länger als breit; das zweite Glied derselben so lang wie breit. Halsschild wenig breiter als lang, runzlig punktiert; seitlich schwach gerundet, die grösste Breite liegt hinter der Mitte; der Vorderrand etwas schmaler als die Basis; diese fein gerandet. Flügeldecken anderthalbmal so lang wie breit, parallelseitig. Punktstreifen ziemlich kräftig, Zwischenräume schmaler als diese, fein entfernt stehend einreihig punktiert.

Färbung schwarz, Flügeldecken mit Bleiglanz. Behaarung kurz greis und wenig aufgerichtet untermischt mit etwas längeren aufstehenden schwarzen Härchen. Länge, 2.5 bis 3.2 Millimeter.

LUZON, Provinz Laguna, Mount Maquiling, Los Baños (*Baker*), 6 Exemplare.

BYCTISCINI

Genus **BYCTISCIDIUS** novum

Kopf konisch; Augen aus der Kopfwölbung nicht hervortretend. Rüssel schlank, länger als das Halsschild. Dieses konisch, vor der Basis am breitesten. Flügeldecken mit verkürztem Nahtstreifen. Epimeren der Mittelbrust von oben sichtbar. Hinterhüften seitlich verkürzt. Typus, *Rhynchites parcus* Voss.

Von *Rhynchites* durch die Hinterhüftbildung der *Byctiscus*-Arten verschieden. Von *Listrobyctiscus* durch den verkürzten Suturalstreifen, das kräftig und sehr dicht punktierte Halsschild, etc., leicht zu trennen. Von *Byctiscus* durch die Halsschildbildung und dem schlankeren Rüssel zu unterscheiden.

Byctiscidius insularis sp. nov.

Kopf zu den Augen konisch verschmälert, hinten äusserst fein und zerstreut punktiert, auf der Stirn etwas kräftiger und dichter. Augen aus der Kopfwölbung nicht hervortretend, auf der Stirn einander genähert; der Zwischenraum fast nur halb so breit wie der Rüssel vor der Basis; etwas längsfurchig eingedrückt. Rüssel leicht gebogen, so lang wie Kopf und Halsschild zusammen, oben glatt, nur seitlich wenig kräftig punktiert. Fühler in der Mitte des Rüssels eingelenkt. Schaftglied sehr kurz, kaum länger als breit, das erste Geisselglied fast doppelt so lang; das zweite und dritte Glied etwas schwächer aber so lang wie das erste Glied, das vierte Glied kürzer; das fünfte Glied noch deutlich länger als breit; das sechste und siebente Glied schwach quer. Keule kräftig; das erste und zweite Glied quer; das dritte Glied kaum länger als breit. Halsschild wenig breiter als lang, seitlich nur schwach gerundet, nach vorn stärker verengt als an der Basis; kurz vor der Basis am breitesten. Punktierung ziemlich kräftig und dicht; auf der Scheibe mit feiner Längsnaht. Basis zum Schildchen etwas geschweift vorgezogen und fein gerandet. Flügeldecken wenig länger als breit, kräftig und dicht reihig punktiert; Zwischenräume schmaler als die Streifen, gewölbt und unpunktiert; etwas verrunzelt. Der vorletzte Punktstreifen vereinigt sich mit dem Randstreifen in der Höhe des dritten Bauchsegments. Pygidium gross, fast länger als breit, senkrecht stehend; dicht und flach punktiert, am Grunde überall fein gekörnelt; ringsum gerandet, an der Basis geschweift. Hinterhüften seitlich stark verkürzt; der vorgezogene Lappen des ersten Abdominalsegments tangiert

auf breiter Basis den Hinterrand der Hinterbrust. Tibien grade; das erste Tarsenglied viel kürzer als das zweite und dritte Glied zusammen.

Färbung schwarz mit leichtem bläulichen Schein. Oberseite unbehaart. Die Mitte des Bauchs, namentlich das zweite bis vierte Abdominalsegment, sind langabstehend büschelförmig behaart. Länge, 2.5 Millimeter.

PENANG (*Baker*), 1 Tier.

Genus **LISTROBYCTISCUS** novum

Kopf konisch; Augen aus der Kopfwölbung nicht hervortretend. Halsschild konisch, schwach gerundet, und meist kräftig zum Kopf verschmälert, in der Regel an der Basis am breitesten, weniger oft etwas eingezogen; beim Männchen bisweilen seitlich mit Dornen bewehrt, die jedoch mehr auf der Unterseite liegen und dadurch weniger leicht sichtbar sind. Rüssel schlank und meist erheblich länger als Kopf und Halsschild zusammen. Flügeldecken ohne verkürzten Nahtstreifen; vorletzter Seitenstreifen verkürzt und meist in der Höhe der Hinterhüften in den Randstreifen eingelenkt. Hinterhüften seitlich verkürzt. Glänzend und unbehaart.

Typus, *Rhynchites corvinus* Pascoe.

Meist hochglänzende, schwarze oder blaue Tierchen, deren Abtrennung von *Rhynchites* sich der verkürzten Mittelhüften wegen, bedingt durch die lappenartige Ausbildung des ersten Abdominalsegments, notwendig macht. Aehnlich wie bei den Bariiden treten die Epimeren der Mittelbrust zwischen Decken und Halsschild höher hinauf und sind von oben stets gut sichtbar.

Listrobyctiscus corvinus (Pascoe).

LUZON, Mount Maquiling (*Baker*), 1 Exemplar.

Die Nominatform ist tiefschwarz gefärbt, und Tiere von Sumatra und Java sind selten mit leichtem bläulichen Schein versehen. Von Sandakan, Borneo, liegen mir jedoch zwei Tiere vor, die schöne tiefblaue Decken haben, sich aber sonst von der schwarzen Form nicht trennen lassen. Sie möge *L. coeruleipennis* forma nova benannt sein.

Listrobyctiscus laevigatus (Pascoe).

In den Arten mit unbewehrtem Halsschild gehörend und sich von *L. corvinus* (Pascoe) durch viel schlankere und gestrecktere Fühler auszeichnend. Die Nominatform wurde von Pascoe mit schwachblauen Decken und im übrigen mehr purpurschwarzem

Körper beschrieben. Mir liegen eine ganze Anzahl Tiere von Celebes, Borneo, und den Philippinen vor, die in den übrigen von Pascoe angegebenen Merkmalen mit der Beschreibung übereinstimmen, jedoch wie *corvinus* tiefschwarz gefärbt sind. Diese Form möge *moris* forma nova benannt sein. Tiere von blauer Färbung liegen mir von Luzon vor: *luzonensis* forma nova (*5936*). Zwei von diesen Tieren weichen in der Fühlerbildung ab: das dritte Geisselglied ist etwas länger als das zweite Glied (bei *laevigatus* Glied 2 gleich 3). Möglicherweise handelt es sich hier um eine neue Art. Die blauen Weibchen werden sich namentlich von den nachstehend beschriebenen Arten mit bei den Männchen bewehrtem Halsschild schwierig trennen lassen. *Rhynchites manillensis* Westwood wird vielleicht auch in diese Gattung gehören.

Die f. *moris* liegt mir von folgenden Fundorten vor:

LUZON, Provinz Laguna, Los Baños, Mount Maquiling: Provinz Tayabas, Malinao (*Baker 4422*). MINDANAO, Iligan (*Baker*), Agusan River (*Bureau of Science 13680 W. Schultze*), 30 September, 1910.

Listrobyctiscus rubriventris sp. nov.

Kopf nur äusserst fein und nicht dicht punktiert; Stirn nur halb so breit wie der Rüssel vor der Basis. Dieser wenig länger als Kopf und Halsschild zusammen, unten gleichmässig gebogen, oben etwas buckelig aufgeworfen. Fühler beim Weibchen in, beim Männchen etwas vor der Mitte des Rüssels eingelenkt. Männchen: Schaft und erstes Geisselglied wenig länger als breit, gleichlang; das zweite und dritte Glied so lang wie das erste; das vierte bis siebente Glied so lang wie breit; zur Keule hin allmählich kräftiger werdend. Das erste und zweite Glied der Keule schwach quer. Weibchen: Das erste Geisselglied viel länger als das Schaftglied; das zweite Glied so lang wie das erste; das dritte Glied kürzer. Halsschild konisch und seitlich nur schwach gerundet, an der Basis am breitesten; äusserst fein und nicht dicht punktiert. Beim Männchen kurz vor dem Vorderrand beiderseits mit einem Dorn versehen. Schildchen quer. Flügeldecken etwa ein-und-ein-drittelmal so lang wie breit. Punktstreifen hinter der Basis kräftig, dann nach hinten viel feiner werdend. Zwischenräume breit, unregelmässig punktiert.

Färbung schwarz; Abdomen mit Pygidium rot. Länge, 3.2 bis 3.5 Millimeter.

MINDANAO, Iligan, Zamboanga (*Baker*), 1 Pärchen.

Listrobyctiscus chalybaeus sp. nov.

Kopf fein und nicht dicht, auf der Stirn etwas kräftiger und dichter punktiert. Augen auf der Stirn einander etwas genähert, Zwischenraum kleiner als der Rüssel vor der Basis breit. Rüssel so lang wie Kopf und Halsschild zusammen; seitlich gesehen zunächst fast grade, dann von der Fühlereinlenkung ab, die etwas vor der Mitte erfolgt, gebogen; von oben gesehen nur kurz vor der Spitze etwas verbreitert; ungekielt, glatt; fein und zerstreut punktiert. Schaft- und erstes Geisselglied etwa gleichlang, länglich oval, doppelt so lang wie breit; das zweite Geisselglied am längsten, verkehrt kegelförmig, das dritte Glied kaum so lang wie das erste Glied; das vierte Glied wenig kürzer als das dritte Glied; das fünfte Glied noch deutlich länger als breit; das sechste Glied so lang wie breit; das siebente Glied kräftiger und etwas breiter als lang. Keule ziemlich kräftig, Glied 1 und 2 schwach quer. Halsschild länger als breit, hinter der Mitte ziemlich kräftig gerundet, zur Basis gerundet verschmälert, zum Vorderrand gradlinig verengt, hier erheblich schmaler als an der Basis. Punktierung ziemlich fein und auch etwas dicht. Kurz vor dem Vorderrand seitlich mit kleinem, nach vorn gerichtetem Dorn bewehrt; Basis fein gerandet. Flügeldecken länglich, fast anderthalbmal so lang wie breit. Punktstreifen im basalen Viertel kräftig, dann ziemlich unvermittelt feiner werdend. Zwischenräume breit und flach; sehr fein, etwas unregelmässig punktiert.

Färbung blau, glänzend; Kopf, Rüssel, Fühler, Tibien, und Tarsen schwarz. Länge, 4 Millimeter.

BASILAN (*Baker*), 1 Männchen.

Listrobyctiscus armaticollis sp. nov.

Kopf sehr fein und nicht dicht punktiert; Stirn erheblich schmaler als der Rüssel vor der Basis dick. Rüssel so lang wie Kopf und Halsschild zusammen, leicht gebogen; auf der Basalhälfte kräftig gekielt, der Kiel läuft zur Stirn hinauf; vorn fein und ziemlich dicht punktiert. Fühler kurz vor der Rüsselmitte eingelenkt. Schaftglied kaum länger als breit, das erste Geisselglied doppelt so lang wie breit; das zweite und dritte Glied etwas kürzer als das erste Glied, untereinander gleichlang und wenig länger als das vierte Glied; das fünfte Glied etwas länger als breit; das sechste Glied so lang wie breit; das siebente Glied quer. Keule ziemlich kräftig, das zweite Glied stärker quer und etwas kürzer als das erste. Halsschild etwas

kräftiger und dicht punktiert; an der Basis etwas eingezogen und wenig breiter als der Vorderrand. Basis fein gerandet. Der Seitenzahn ist klein und spitz und steht mehr seitlich im vorderen Drittel. Flügeldecken etwa anderthalbmal so lang wie breit, seitlich schwach gerundet. Punktierung auf der Basalhälfte kräftig, hinten viel feiner. Zwischenräume einreihig punktiert.

Färbung schwarz; Flügeldecken bläulich Länge, 2.5 Millimeter.

LUZON, Mount Banahao (*Baker 5937*), 1 Männchen.

Listrobyctiscus tibialis sp. nov.

Kopf nur fein, flach und ziemlich dicht punktiert. Rüssel länger als Kopf und Halsschild zusammen, auf der Basalhälfte gekielt, auch die Seitenränder scharf kielartig aufgeworfen. Fühler kurz vor der Rüsselmitte eingelenkt. Schaftglied wenig länger als breit; das erste bis dritte Geisselglied viel länger als das Schaftglied und untereinander gleichlang; das vierte und fünfte Glied länger als breit; das sechste Glied so lang wie breit; das siebente Glied viel stärker, zur Keule übergehend. Keule gedrungen, Glied 1 und 2 quer. Halsschild fein und dicht punktiert, seitlich gerundet, zur Basis gerundet verengt; am Vorderrand etwas schmaler als an der Basis. Der seitliche Dorn befindet sich dicht vor dem Vorderrand und ist etwas auswärts gerichtet. Schildchen stark quer, viereckig. Flügeldecken bei dieser Art länger, seitlich parallel, wohl ein-und-dreiviertelmal so lang wie breit. Punktierung auch vorn weniger stark; Zwischenräume viel breiter als die Streifen, ein- bis zweireihig punktiert. Die Hintertibien weisen bei dieser Art in der Mitte der Innenseite einen kräftigen Buckel auf; die Spitze trägt einen kleinen Dorn.

Färbung schwarz; Flügeldecken blau. Länge, 4 Millimeter.

LUZON, Provinz Laguna, Mount Maquiling (*Baker 2223*), 1 Männchen.

ADDITIONS TO THE HERPETOLOGICAL FAUNA OF THE PHILIPPINE ISLANDS, III

By EDWARD H. TAYLOR
Of Manila, Philippine Islands

THREE PLATES

This is the third[1] of a series of papers embodying results of a study of the collections made by myself in the Philippines in 1920, 1921, and 1922.

In this paper the following species are described as new:

AMPHIBIANS

Ichthyophis glandulosus.
Rana woodworthi.
Rana acanthi.
Rana micrixalus.

LIZARDS

Lepidodactylus herrei.
Mabuya bontocensis.
Sphenomorphus stejnegeri.

SNAKES

Cyclocorus nuchalis.
Calamaria polillensis.
Calamaria hollandi.
Boiga schultzei.

The following species are listed with notes on color, scalation, and habitat. Other pertinent data are also recorded.

AMPHIBIANS

Rana vittigera Wiegmann.
Rana magna Stejneger.
Rana leytensis Boettger.
Rana similis (Günther).

LIZARDS

Hemidactylus garnotii Duméril and Bibron.
Peropus mutilatus (Wiegmann).
Cosymbotus platyurus (Schneider).
Gekko gecko (Linnæus).
Draco bimaculatus Günther.
Gonyocephalus interruptus Boulenger.
Otosaurus cumingii Gray.
Sphenomorphus decipiens (Boulenger).
Sphenomorphus curtirostris Taylor.

[1] Taylor, Edward H., Additions to the herpetological fauna of the Philippine Islands, I, Philip. Journ. Sci. 21 (1922) 161–206; II, ibid., 21 (1922) 257–303.

LIZARDS—continued

Sphenomorphus atrigularis Stejneger.
Sphenomorphus steerei Stejneger.
Sphenomorphus biparietalis Taylor.
Sphenomorphus fasciatus (Gray).
Sphenomorphus variegatus (Peters).
Leiolopisma pulchellum (Gray).
Tropidophorus grayi Günther.
Tropidophorus rivularis Taylor.
Brachymeles eleræ Taylor.

SNAKES

Typhlops braminus (Daudin).
Natrix auriculata (Günther).
Cyclocorus lineatus (Reinhardt).
Hurria rynchops (Schneider).
Hurria microlepis (Boulenger).
Holarchus ancorus (Girard).
Boiga cynodon (Boie).
Laticauda semifasciata (Reinwardt).

AMPHIBIANS

Ichthyophis glandulosus sp. nov. Plate 3, figs. 4, 5.

Type.—No. 1595A, E. H. Taylor collection; collected at Abungabung, Basilan, October 23, 1921, by Edward H. Taylor.

Description of type.—Head rather triangular, the snout conical; nostrils very far forward, the distance between them a little less than half the distance between eyes and slightly more than half the distance nostril to eye; eye very small, dim, the pupil and iris not distinguishable, the distance between eyes equal to their distance from end of snout; exsertile tentacle very close to mouth, the distance from eye less than half its distance from nostril; eye and nostril on a level, equidistant from commissure of mouth; nostril directed upward; at some distance behind angle of jaws a strong groove about the head, continuous save in the midoccipital region; posterior to this a second, very strong groove crosses throat, extending some distance on the upper surface of head; a third, ill-defined groove behind this delimits neck; skin of body smooth with 273 small transverse folds from neck to tip of tail, the folds forming a median dorsal angle save on the anterior and posterior parts of body; the folds on the belly are very indistinct; the angle formed is directed backward, while on the back the angle formed by the junction of the folds is directed forward; tail very short, ending bluntly; anal opening a longitudinal slit; on each side of body is a broad dorsolateral glandular fold which extends from head along body to a point a short distance in front of tail; this fold is strongly defined, of equal prominence its entire length; upper jaw with two well-developed series of teeth, the inner series extending slightly farther back than the outer; lower

jaw with a strongly developed outer series and a short inner series of teeth.

Color in life.—Deep lavender to slate; more olive than lavender below. In formalin the specimen is brownish lavender with scattered deep purple markings.

Measurements of the type of Ichthyophis glandulosus sp. nov.

	mm.
Total length	250
Tail from end of anus	4
Width of body	12
Distance between nostrils	2.9
Distance between eyes	6
Nostril to eye	4.5
Eye to end of snout	6
First neck groove to tip of lower jaw	8
Second neck groove to tip of lower jaw	10.5
Third neck groove to tip of upper jaw	17
Width of glandular fold	3
Distance between folds	6.5
Diameter of eye	0.7

Variation.—There are four specimens in the collection, all collected in the same immediate locality. One is young, 165 millimeters in length. It is of a deep slate-purple color. The glandular folds are present. The posterior part of the head is less widened than in the adult specimens.

Remarks.—I have with some hesitancy described this as a new species, not having comparative material of *Ichthyophis monochrous* Bleeker. There appears to be no complete description of that species (unless it be the type description, which I do not have). This new species seems to differ from *I. monochrous* in the presence of the two dorsolateral glandular folds and in having the distance between eyes equal to the length of snout instead of greater.

From *Ichthyophis weberi* Taylor it differs in having two rows of teeth instead of a single row in the lower jaw, in the presence of dorsolateral glandular folds, and in the shape of the head. In *I. weberi* the sides of the head are more nearly parallel, and the snout is more rounded, the grooves on the neck are very dim, and the eye is very distinct.

Specimens were collected under logs in moist situations along a small forest stream in southern Basilan. Mr. Hamilton, who had established the logging camp at Abung-abung, told me that he had frequently seen specimens of this species when digging trenches to drain a small swampy area near the camp.

Rana vittigera Wiegmann.

Rana vittigera WIEGMANN, Nova Acta Acad. Leop. Carol. (1836) 225, pl. 21, fig. 1; TAYLOR, Philip. Journ. Sci. 16 (1920) 236, pl. 2, fig. 3; Amphibians and Turtles of the Philippine Islands (1922) 37.

In the recent papers of Anandale[2] and Boulenger[2] on the identity of *Rana tigrina* Daudin and the allied forms, considerable light has been thrown on a difficult subject. In as much as certain of their conclusions affect the specific designation of two Philippine frogs—namely, *R. vittigera* Wiegmann and a form which I have named *R. moodiei*—I deem it wise to reassert my opinion in the light of these publications. My study of these two forms was made and published before I had seen any of the papers mentioned; in fact, I had had no copy of Wiegmann's paper describing the species.

I recently obtained a copy of Wiegmann's description and figure, and I am now more than ever convinced that the species *Rana vittigera* Wiegmann is distinct from *R. tigrina* and its allied forms and that Wiegmann's name should be applied to it.

Wiegmann's specimens, from which he drew his type description and from which his figure was drawn, appear to have been taken at Laguna de Bay, Luzon. He states:

> Diese Art findet sich sowohl auf der Insel Luzon in der Laguna de Bay, als auch in China; an beiden Orten wird sie häufig gegessen, und besonders auf dem Markte von Macao wird sie täglich zu Tausenden verzehrt.

Many specimens I have taken near Laguna de Bay agree with the drawing given in Plate 21, fig. 1, of Wiegmann's paper in marking, the folding of the skin, the shape of the head, and the general contour of the body. There is no free dermal fringe along the outer edge of the fifth toe which occurs in *R. tigrina* and allied forms. There is, however, a slight dermal fold, but this is in no way similar to the membranous fringe on the outer side of the toe in *R. tigrina* and *R. moodiei.*

Wiegmann himself points out the similarities and differences between *Rana vittigera* and *R. limnocharis.* However, if it has been or can be proved that these two forms are identical, the name *R. vittigera* will be used instead of *R. limnocharis.* In fact, *R. limnocharis* is attributed to Boie,[3] but I find that the species has always been attributed by subsequent authors to Wiegmann. I presume that, as far as Boie is concerned, the name is a nomen nudum. There is no outer metatarsal tubercle

[2] Rec. Ind. Mus. 15[2] (1918) 51–67. [3] Wiegmann loc. cit.

present in the Philippine *R. vittigera;* it is said to be present in *R. limnocharis.*

Regarding *Rana moodiei* I am not so certain. This species occurs in central Luzon probably as frequently as does *R. vittigera.* It would appear that Wiegmann, if he obtained specimens, lumped them with *R. vittigera* just as other writers have lumped the two forms under *R. tigrina.*

That the two species *Rana vittigera* and *R. moodiei* are distinct cannot be questioned. That *R. moodiei* is distinct from Boulenger's varieties of *R. tigrina* or of Anandale's related species, I am not so certain. I am submitting specimens to Dr. Malcolm Smith, of Bangkok, Siam, in order that comparisons can be made.

I also do not agree with Boulenger in regarding the two forms figured by Wiegmann on Plate 21, figs. 1 and 2, as identical species. Had the specimen illustrated by fig. 2 been taken in the Philippines I should declare it *Rana moodiei,* since that species differs from *R. vittigera* as the two figures differ from each other.

Rana woodworthi sp. nov. Plate 1, figs. 1, 2.

Type.—No. 1921, E. H. Taylor collection; collected near Los Baños, Laguna Province, June 12, 1921, by Edward H. Taylor.

Description of type.—Choanæ small, widely separated, not concealed by overhanging jaw; vomerine teeth in two series beginning near inner anterior border of choanæ, but separated from them by a distance equal to half the diameter of choanæ and extending much behind their posterior level, separated narrowly from each other; tongue with two rounded posterior horns widely separated at base; two moderately prominent teeth in anterior part of lower jaw; openings of vocal sacs very small, near angle of mouth; snout rather long, pointed; canthus rostralis very prominent, angular; upper part of lores nearly perpendicular, lower part sloping obliquely to mouth; a slight groove between eye and nostril; eye rather small, its diameter equal to distance from eye to slightly beyond nostril; distance from nostril to tip of snout contained nearly twice in distance between eye and nostril; distance between nostrils equal to their distance from eye, as well as to the height of snout in front of eyes; tympanum distinct, its diameter equal to little more than half the diameter of orbit, separated from eye by a distance equal to two-thirds the diameter of tympanum; width of upper eyelid one and one-third times interorbital distance; skin

of head very smooth; posterior part of eyelid with tubercles; loreal region with very slight tuberculation; a dim fold connecting posterior corners of eyes; a distinct dorsolateral glandular fold from eye, continuing two-thirds the length of body; a stronger supratympanic fold, separated from the dorsolateral fold, goes from eye to insertion of arm, forming an obtuse angle above tympanum; a slight ridge on posterior part of lower jaw continuing in a straight line to arm as a glandular fold, separated from supratympanic fold posteriorly by a narrow groove; skin on anterior part of body nearly smooth; skin on posterior part of back and upper surface of tibia covered with numerous minute tubercles with occasional larger ones; certain of those in middle part of back arranged in two longitudinal rows; chin, throat, breast, belly, and underside of limbs entirely smooth; fingers terminating in small rounded knobs, first finger distinctly longer than second but scarcely reaching penultimate tubercle on third; subarticular tubercles moderate, carpal tubercles rather indistinct; toes about four-fifths webbed, the web reaching a short distance below tip of third, and slightly beyond penultimate tubercle on fourth; subarticular tubercles strong; inner metatarsal tubercle elongate, little more than one-third the length of first toe; toes with small knobs at tips; no outer metatarsal tubercle; a distinct skinfold on outer side of fifth toe; a slight fold from metatarsal tubercle to near keel; hind limb brought forward tibiotarsal articulation reaches to nostril.

Color in life.—Above gray-lavender with very dim darker markings; a dark loreal streak and a large dark spot from eye to arm involving tympanum; three large spots on upper and lower lips; a dark spot above insertion of arm; limbs barred full length; posterior aspect of femur dark purplish with a longitudinal yellow streak; a yellow streak on the glandular fold behind angle of jaws; underside of forearm very dark with a row of very small yellow dots; chin and breast dusky, mottled with purple; underside of hands and feet purplish; a small yellow spot between and slightly anterior to eyes.

Variation.—The chief variation noted is in color. Certain specimens have the body brownish lavender with islandlike spots over the entire back; some have a V-shaped mark on the shoulders. The strong tympanic spot is invariably present and is usually very sharply defined, especially in young specimens. There are usually some deep black spots in the groin. The loreal streak is constant.

Measurements of three specimens of Rana woodworthi sp. nov.

	No. 1921, type.	No. 1922.	No. 1928.
	mm.	*mm.*	*mm.*
Snout to vent	69	69	57
Snout to eye	11	11	9
Diameter of eye	9	8.9	7
Length of head	31	30	23
Width of head at tympanum	26	26	20
Depth of head in front of eye	7.5	7.5	6
Eye to nostril	6.8	7	5.1
Upper eyelid	6.8	7	5
Interorbital space	58	5.5	4.2
Forelimb	41	40	32
Longest finger	17	16	13.5
Hind limb	112	115	99
Femur	36	37	28
Tibia	36	38	31
Longest toe to metatarsal tubercle	34	36	28

Specimens from Polillo Island agree very well in general contour and markings. The eyelids, however, are a little narrower, practically equaling the interorbital distance; the first finger is slightly longer proportionally, reaching beyond the penultimate subarticular tubercle on the third finger.

In my previous works on Philippine Amphibia [4] I confused this species with *Rana leytensis* which apparently does not occur in Polillo.

Remarks.—The frogs of the *Rana tigrina* group which occur throughout southern Asia and in the archipelagoes are no more difficult to differentiate than are those belonging to the *R. macrodon* group. It has been the custom of most systematists, at least when dealing with Philippine specimens, to lump together under the name of *R. macrodon* all species having the enlarged bony prominences in the lower jaw.

Stejneger [5] described the large Philippine frog occurring generally over the Islands (listing Mindanao, Basilan, Mindoro, and Luzon) under the name *Rana magna.* He differentiates the form from *R. macrodon* Duméril and Bibron, but does not mention the relationship with *R. modesta* Boulenger which was described from Celebes by Boulenger.[6]

[4] Philip. Journ. Sci. 16 (1920) 248; Amphibians and Turtles of the Philippine Islands (1922) 49.

[5] Smithson. Misc. Col. 52 (1909) 437.

[6] Proc. Zool. Soc. London (1897) 228.

When I prepared my description of *Rana magna* for my Philippine Amphibia,[7] I had before me specimens of this new species and a large series of specimens belonging to *R. magna,* both of which at that time I regarded as merely geographical and age variations of *R. magna.* The principal variations were recorded.

In my collections made in 1921 on and about Mount Maquiling I noted that two distinct forms occurred in the same locality, and with large series of both it was possible to separate the two forms without difficulty.

Rana woodworthi differs from the species which I identify as *R. magna* Stejneger in the presence of a dorsolateral glandular fold, a smaller eye, a less-pointed snout, a loreal streak, and a strong tympanic spot. In *R. magna* the toes are webbed to the tip. In specimens of the two species having the same snout-to-vent measurements *R. magna* is less slender, and somewhat shorter limbed. The young of *R. magna* do not have dorsolateral folds!

The type specimen was collected from a small, nearly dry stream bed which lies between Camp Eldrige, Los Baños, and the College of Agriculture. The frogs were perched along the edge of small stagnant pools. Numerous specimens were taken.

The species is named for Harold Evans Woodworth, professor of entomology, College of Agriculture, Los Baños.

Rana magna Stejneger. Plate 1, fig. 3.

Rana magna STEJNEGER, Smithson. Misc. Coll. 52 (1909) 437; TAYLOR, Amphibians and Turtles of the Philippine Islands (1922).

I collected specimens of this species in Kalinga, Bontoc, Ifugao, and Benguet Subprovinces, Laguna and Bataan Provinces, Luzon Island; and on Polillo, southeastern Mindanao, and Basilan Islands. I have recently obtained specimens from southern Negros through the courtesy of Dr. Albert C. Herre.

The specimens vary more or less in the character and number of the tubercles on the back, the relative position and size of the tympanum, and the size of the eye in relation to the length of the snout. In the material at hand I have been unable to find stable characters that would separate the species into varieties. In Palawan a related species occurs which has been regarded by other authors as *Rana macrodon.* It is, however, well differentiated from that species by the presence of the vocal sacs in the male and the absence of well-defined canthi rostrales. It is described in this paper as *R. acanthi* sp. nov.

[7] Philip. Journ. Sci. 16 (1920) 243, pl. 2, fig. 2.

Specimens of *Rana magna* usually are discovered perched on banks of small mountain streams in which they take refuge on the approach of anyone. The frog is sought for food all over the Islands, and very large specimens are rare.

Specimens from northern Kalinga appear to have better-developed spiny tubercles over the body than the southern specimens, particularly in the latter half of the back. Specimens from Ifugao, obtained by Prof. H. Otley Beyer, appear to represent a distinct species. However, the specimens are all young, and the fixing fluid has hardened them. I await more material before disposing of these forms.

Rana acanthi sp. nov. Plate 2, fig. 1.

Type.—No. 539, E. H. Taylor collection; collected on Busuanga Island, Calamian Islands, by Edward H. Taylor.

Description of type.—Choanæ large, rounded; vomerine teeth in two elongate, oblique series, beginning near anterior inner border of choanæ and lying between and behind choanæ, separated from each other by a distance equal to less than one-third the length of a single series; tongue large, with two elongate horns separated at base; no tubercles; openings of vocal sacs moderately large; two sharp-pointed fanglike teeth in anterior part of lower jaw, head strongly widened in tympanic region; snout rounded when seen from above in lateral profile; canthus rostralis not distinct, rounded; nostrils nearer end of snout than eye; eye moderately large, its diameter equal to distance from eye to beyond nostril; tympanum small, less than two-thirds eye (on right side tympanum is indistinguishable), separated from eye by a distance greater than half its diameter; a strong fold from eye to insertion of arm, forming an angle above tympanum; snout smooth; posterior part of eyelid granular; loreal region slightly concave, sloping very obliquely to mouth, slightly granular; an indistinct V-shaped fold on back followed by two series of distant rounded tubercles which extend to anus; sides and temporal region with short longitudinal folds; very minute scattered tubercles on leg; a slight glandular tubercle behind angle of mouth; a few inconspicuous folds below angle of jaw; belly, chin, throat, and underside of limbs entirely smooth; side with two rows of tubercular granules terminating in groin; fingers slender, terminating in small rounded knobs, not wider than digits; first finger much longer than second, extending as far as fourth; subarticular tubercles well developed; carpal tubercles indistinct; toes about two-thirds webbed, the web reaching the tips by very slender margins on outer side of

first, second, and third toes; an elongate inner metatarsal tubercle, followed by a small fold on heel; a well-defined skin flap on outer side of fifth toe; no outer tubercle; tibiotarsal articulation reaches tip of snout.

Color in life.—Above mottled gray to gray-brown with indistinct dark markings; a broad cream-yellow line runs from snout to anus, the edges not sharply defined, and more or less mottled and marked with darker; markings on lips very indistinct; tympanum brown; throat dirty gray-white, belly, under thigh, and groin canary to lemon yellow; limbs very dimly barred with darker.

Measurements of type of Rana acanthi sp. nov.

	mm.
Snout to vent	73
Snout to eye	12
Diameter of eye	10
Eye to nostril	8
Upper eyelid	6
Interorbital distance	6
Length of head	31
Width of head	29
Forelimb	41
Hind limb	114
Tibia	38
Femur	36
Longest toe to end of metatarsal tubercle	35

Variation.—There is at hand a good series of young and half-grown specimens from northern Palawan and Busuanga. The characters recorded for the type are evident in most of them. The broad stripe on the back is absent in only one of the larger specimens, but is wanting in several of the smaller specimens. The development of the two teeth in the anterior part of the lower jaw depends upon age and sex, being largest in the older males. Two of the specimens are almost uniform gray-brown above, with the cream-yellow stripe and a light area above the arm and below the posterior part of the eye; the bars on the leg are more strongly marked than in the type.

Remarks.—This belongs to the *Rana macrodon* group of frogs, characterized by the enlarged teeth in the lower jaw, the skin flap on the outer toe, and the absence of the outer metatarsal tubercle. The Philippine forms, *R. magna* Stejneger, *R. woodworthi* sp. nov., and the present species differ from *R. macrodon* in having vocal sacs. *R. acanthi* sp. nov. differs from the two Philippine species in the presence of the broad medial stripe

(which is invariably absent in *R. magna* and *R. woodworthi*), in the absence of angular canthi rostrales, and in the arrangement of the dorsal skin folds. The leg is longer than in *R. magna*, and the dorsolateral fold of *R. woodworthi* is absent. The webbing of the toes is much the same as in *R. woodworthi* but less than in *R. magna*.

The specimens were collected about a small sluggish stream. Many that were seen escaped capture by diving in the water and remaining under for a considerable time.

Rana leytensis Boettger.

Rana leytensis BOETTGER, Zool. Anz. (1893) 365; BOULENGER, Proc. Zool. Soc. London (1897) 228; TAYLOR, Philip. Journ. Sci. 16 (1920) 246, pl. 2, fig. 1.

The type of this species from Leyte measured 28 millimeters, and the largest one of the specimens reported by Boulenger, from Celebes, measured only 38 millimeters. Philippine specimens for the most part appear to attain a larger size. Most of the adults in my collection from Zamboanga and Basilan average about 50 millimeters while the largest specimen (from Abung-abung, Basilan) measures 56 millimeters. The specimens show the same color variations as recorded by Boulenger. Some have a more or less continuous dorsolateral fold, but in by far the greater number the folds are broken and more or less irregularly arranged. The V-shaped mark on the shoulders is present.

The specimens from Jolo were collected for the most part on the top of Bud Daho, an old volcanic crater with an elevation of about 600 meters. These are very much smaller than the Zamboanga and Basilan specimens, are lighter in color, and the pads on the toes are appreciably larger. The largest of thirty-four specimens measures only 39 millimeters.

I have called attention to the presence of the enlarged teeth in the lower jaw of this species,[8] which are plainly visible in specimens measuring between 40 and 50 millimeters in length; smaller male specimens show the teeth to some degree.

I have examined two specimens from Sibuyan Island, which I have doubtfully referred to this species. They are immature, and one of them has the digit of the legs obviously deformed. More material must be obtained before this point can be decided. Specimens of the Polillo frog which I referred to this species belong to the species *Rana woodworthi* sp. nov.

[8] Loc. cit.

Rana micrixalus sp. nov. Plate 2, figs. 2, 3.

Type.—No. 1598A, E. H. Taylor collection; collected at Abung-abung, Basilan, October 20, 1920, by Edward H. Taylor.

Description of type.—Choanæ small, only partially concealed by overhanging jaw; vomerine teeth distinct, in two oblique series lying between and behind choanæ, separated from each other by a distance only little less than the length of one series; tongue oval with two slight horns, widely separated at base; no tubercle on tongue; snout short, rounded; nostril distinctly lateral, about equidistant from eye and tip of snout; canthus rostralis rounded; loreal region sloping slightly; tympanum large, distinct, more than three-fourths diameter of eye, separated from eye by a distance equal to little more than one-third diameter of tympanum; eye small; upper eyelid contained in interorbital distance one and one-half times; diameter of orbit equal to its distance from anterior edge of nostril; skin above very minutely granulate, nearly smooth on head, but with large pustular tubercles on back; a pair of large pustular tubercles forming an indistinct V-shaped mark on shoulders; a very broad glandular dorsolateral fold from eye to near anus; a supratympanic fold, from eye to insertion of arm, in the form of a curve which covers edge of tympanum; it forms an angle above arm and ends in a tubercle; two glandular tubercles at angle of mouth; arm granular above; tibia with two prominent enlarged tubercles and several smaller ones; tips of fingers ending in small rounded knobs; hand without webs; first finger longer than second; subarticular tubercles very large, well developed; a strong inner carpal tubercle and a small rounded outer; toes with tips dilated into small disks; subarticular tubercles well developed, toes about half webbed, the membrane not reaching any of the disks save as a narrow margin; no skin fold on outer side of fifth toe; a prominent inner metatarsal tubercle, outer apparently wanting; a slight skin fold on heel continued from metatarsal tubercle; the leg brought forward, the tibiotarsal articulation reaches beyond tip of snout; a distinct fold from angle of mouth across breast.

Color in life.—Above mottled lavender, darker on head; tubercles on back purplish; below dorsolateral folds and on side of head purplish, darker anteriorly; tympanum brown; throat purplish with yellow spots on jaws and throat; belly yellow to flesh; outer end of femur purplish; palms and soles purplish; limbs above barred with purple.

Measurements of type of Rana micrixalus sp. nov.

	mm.
Snout to vent	28.5
Length of head	11.5
Width of head at tympanum	11.5
Diameter of orbit	3.5
Length of snout	5.5
Upper eyelid	2.4
Interorbital distance	3.6
Forelimb	18
Longest finger, to wrist	12.5
Hind limb	53
Femur	14.5
Tibia	17
Longest toe	14

Variation.—There are three specimens in the collection from Abung-abung, Basilan, and two from Pasananka, Zamboanga. No. 1598C is light brownish lavender above, with the same color on the sides, growing lighter, and dusted with minute purple blotches; the lores are purplish; the edge of the lower jaw is dark with yellow spots; throat flesh color; anal region dark; limbs barred above with darker lavender. No. 1598B has a dark purplish streak below the dorsolateral fold. The tubercles on the back are indistinct.

The Zamboanga specimens are the younger. In No. 1060 the tubercles on the back are very dim; the throat and chest are dusky. No. 1135 is brownish above, with a dim interorbital bar and a strong V-shaped black spot over the flat tubercles between the shoulders.

Remarks.—The species appears to be related to *Rana parva* Taylor and *R. mindanensis* Girard. From *R. parva* it differs in having the broad dorsolateral glandular fold, the more-backward position of the nostril, a rough skin with tubercles, the longer hind leg with the tibiotarsal articulation reaching beyond the tip of the snout, and in the presence of a fold on the breast. From *R. mindanensis* it differs in having a narrower eyelid, a wider interorbital area, and the toes half webbed instead of fully webbed.

In general form this species resembles a species of *Micrixalus*. The presence of the vomerine teeth however makes it a true *Rana*.

The specimens collected were hopping about in the forest, away from the immediate vicinity of water. I failed to find the species in Jolo.

Rana similis (Günther).

Polypedates similis GÜNTHER, Proc. Zool. Soc. London (1873) 171.
Rana similis TAYLOR, Philip. Journ. Sci. 16 (1920) 271.

Numerous specimens of this species were collected on Polillo Island, and on Mount Maquiling, Luzon. They were invariably found near water. They frequent grass and débris along streams and rarely or never enter water to escape pursuit. No eggs or larvæ were found, although a pair of the frogs was found copulating in Polillo early in August, 1920. The largest two specimens taken measure approximately 54 millimeters from snout to vent.

I collected a very immature specimen of *Rana* in northern Kalinga Subprovince, which I believe belongs to this species. The characteristic dorsolateral cream lines are invariably present in all specimens taken.

LIZARDS

Hemidactylus garnotii Duméril and Bibron.

Hemidactylus garnotii DUMÉRIL and BIBRON, Erp. Gén. 3 (1836) 368; TAYLOR, Lizards of the Philippine Islands (1922) 56.

Three specimens of this very rare species were collected in southern Ifugao, in an old school building near the forest. It was not encountered elsewhere during my collecting in 1920 and 1921. I have mentioned that I had examined a specimen from Ifugao with preanal pores.[9] This refers to one of the three specimens mentioned above.

All three specimens have femoral pores, thirteen to sixteen on a side. I am still in doubt as to whether this is the true *Hemidactylus garnotii* Duméril and Bibron, which is said to be without femoral or preanal pores. The type locality is Tahiti, and Stejneger's specimens from the Hawaiian Islands presumably included males and females. None of these had pores. It is not improbable that more than one species is represented and that the specimens at hand are not true *H. garnotii* but *H. gaudama* of Theobald. This is a point I cannot decide, having no comparative material at hand.

Peropus mutilatus (Wiegmann).

Hemidactylus mutilatus WIEGMANN, Herp. Mex. 1 (1834) 54.
Peropus mutilatus TAYLOR, Lizards of the Philippine Islands (1922) 62.

I collected this species in practically every locality where collecting was done. It was found under the bark of forest

[9] Op. cit. 59.

trees, as well as in human habitations. This is the only one of the domestic geckos that I have found in numbers in forests away from human habitations. I believe it one of the "aboriginal" species and not one whose arrival has depended on its dispersal by man.

Cosymbotus platyurus (Schneider).

Stellio platyurus SCHNEIDER, Amph. Phys. 2 (1792) 30.
Cosymbotus platyurus TAYLOR, Lizards of the Philippine Islands (1922) 59.

Specimens were obtained from Jolo, Sibuyan, southern Negros, and Manila. The distribution is apparently not general in the Philippines. In my ten years' collecting in the Islands I have never encountered a specimen of this species in the forest away from human habitation.

Lepidodactylus herrei sp. nov.

Type.—No. 480, Bureau of Science collection; collected March 14, 1922, at Luzurriaga, Oriental Negros, by Albert C. Herre.

Description of type.—Snout long, rather conical; rostral low, much broader than high, entering nostril, lowest medially; rostral followed by a large rounded internasal which lies between posterior parts of rostral and supranasal; a second, very small scale also joins rostral on the right side of the large scale; nostril surrounded by a supranasal, two postnasals, first labial and rostral; twelve upper labials; eleven lower labials; four rows of rounded scales on chin, lying anterior to a line drawn across jaw between the sutures of third and fourth labials; mental distinct from labials; about thirty-two rows of longitudinal granules cross snout in front of eye; granules on occiput smaller than those on snout; much smaller than those on back; scales on belly rounded, subimbricate, forming straight longitudinal lines; auricular opening small, rounded; preanal and femoral pores large, in a continuous series, forming a median curved arch, and then curving up on femur from the seventh pore; nineteen pores on right side, twenty on left; in preanal region the pore scales are followed by an angular series of eight enlarged scales which are followed by seven other series of scales that gradually diminish in size to anus; two flattened tubercles at base of tail; tail rounded above, flattened below, with a slight, nonserrate, flattened edge; no spiny scales; annulations not or scarcely evident; the tip of tail with two short regenerated areas; twelve lamellæ under longest finger, a slight

web between fingers; thirteen and fourteen lamellæ under longest toes, web between toes somewhat more extensive than that between fingers; no skin fold on leg; anterior lamellæ divided; granules on back as large as or larger than belly scales.

Color (freshly preserved in alcohol).—Above light grayish lavender from occiput to tip of tail, the pigment very equally distributed, with no markings evident; yellowish between eyes and on snout; a broad, very well defined cream stripe from nostril to above tympanum, where the stripe begins to narrow gradually and continues along a single row of granules to above insertion of foreleg; stripe edged above and below with darker; side of head and labials whitish; sides of neck with a strong wash of lemon yellow; a wash of lemon yellow from axilla to groin; chin, throat, and belly whitish; underside of tail uniform salmon.

Measurements of the type of Lepidodactylus herrei sp. nov.

	mm.
Total length	97
Snout to vent	48
Tail	49
Snout	5.5
Diameter of eye	3.5
Eye to auricular opening	4
Snout to foreleg	20
Axilla to groin	22.5
Foreleg	12.5
Hind leg	19
Length of head	14.5
Width of head	10

Remarks.—This species is related to *Lepidodactylus aureolineatus* Taylor, but differs in certain salient points. The head is longer and more conical; the line through the eye is wider and more pronounced; the character of the tail is different, lacking the prominent lateral spines which mark the annulations in *L. aureolineatus;* the granules on the back are much larger in comparison to the ventral scales. By count *L. aureolineatus* has approximately 150 to 155 rows of granules and scales about the middle of the body, while *L. herrei* has between 70 and 80, depending on the point where the count is made. I suspect that it is a larger species, since it much exceeds the size of some eleven specimens of *L. aureolineatus* that I have been able to examine.

The single (type) specimen was collected by Dr. Albert C. Herre, chief of the division of fisheries, Bureau of Science. The

species is named for its discoverer who very kindly permitted me to describe it.

Gekko gecko (Linnæus).

Lacerta gecko LINNÆUS, Syst. Nat. ed. 10, 1 (1758) 205.
Gekko gecko TAYLOR, Lizards of the Philippine Islands (1922) 94.

This common species was collected in Manila and Los Baños, Luzon, and on Jolo Island. It appears to be absent from Kalinga and Polillo. I heard the call of this species many times in the vicinity of the town of Zamboanga, but no specimens were taken. None were seen or heard in the forests to the north of Zamboanga or in Basilan.

In my work on Philippine lizards I suggest that *Gekko gecko* is of comparatively recent introduction since it is seldom found at any considerable distance from human habitation. It is quite unknown in central eastern Mindanao, away from the coasts.

Draco bimaculatus Günther.

Draco bimaculatus GÜNTHER, Rept. Brit. India (1864) 127; TAYLOR, Lizards of the Philippine Islands (1922) 126.

This species was collected near Pasananka, Zamboanga, at Abung-abung, Basilan, and on Mount Tumantangis, Jolo.

Most of the Zamboanga specimens were shot from coconut trees. Not infrequently this species and *Draco rizali* were collected from the same tree. In Basilan specimens were collected from the trunks of forest trees. Sometimes three or four specimens were observed in the same tree, particularly in cutover areas where most of the larger trees had been removed. Only a single specimen was collected in Jolo. It was obtained for me by Mr. Alexander Schuck from a large forest tree at an elevation of about 600 meters, on Mount Tumantangis. Mr. Schuck shot it from the tree with a forty-five revolver. The specimen was uninjured save for a broken leg. A specimen of this species was collected at Cabalian, Leyte, by Gregorio Alforo y Lopez.

Males and females agree very well in color save that in the females the throat is crossed by two deep bluish black lines.

Gonyocephalus interruptus Boulenger.

Gonyocephalus interruptus BOULENGER, Cat. Liz. Brit. Mus. ed. 2, 3 (1885) 290, pl. 22; TAYLOR, Lizards of the Philippine Islands (1922) 134, pl. 9, fig. 1.

Only an immature specimen of this species was collected. It was found near Pasananka, Zamboanga. The division between

dorsal and nuchal crests is distinct, although the crests are very low. There is a distinct dorsolateral row of tubercular scales on the back paralleling the dorsal crest; on the sides there are several enlarged tubercles arranged in irregular transverse rows. The color in life was brownish red above extending low on the sides. The top of the head was brick red; the labials and the area below the eye yellow-green; the tympanum bright yellow; the bars crossing the head yellow; the marks on the back dull yellow to olive; the bars on the tail gray.

It would appear that certain specific characters of Peters's *Gonyocephalus semperi* are incorporated in this specimen. Unfortunately, the species is rare, and it is very difficult to obtain large series from the various islands. It may be that this and Peters's species will have to be united.

Mabuya bontocensis sp. nov.

Type.—No. 696, E. H. Taylor collection; collected along the Mountain Trail, Bontoc Subprovince, Mountain Province, April, 1920, by Edward H. Taylor.

Description of type.—Rostral visible above, much widened at its base; internasals small, widely separated; frontonasal longer than wide, forming a curved suture with rostral; prefrontals rectangular, placed diagonally, separated medially; frontal elongate, more than twice as long as broad, distinctly longer than its distance from end of snout, in contact with frontonasal; frontoparietals distinct, small; interparietal very small, scarcely longer than wide, partially fused with parietals; latter very much broader than deep, followed by a pair of nuchals equally broad and only slightly shorter; nostril in a single nasal, separated from supranasal and first labial by only an extremely narrow rim of the scale; no postnasal; two loreals, the anterior higher but smaller than the second; latter followed by two suboculars; four superciliaries; four supraoculars, the first small, the second very large forming a suture with prefrontal, separating first supraocular from frontal; third and fourth small, not touching frontal; four subequal labials in front of the large labial under eye which is four or more times as long as high; subocular followed by a single small labial; latter separated from parietal by two slightly enlarged temporals; posterior temporal series not or scarcely larger than body scales; anterior edge of nostril on a line with the suture formed by rostral and first labial; mental large, followed by large postmental; six lower labials; two pairs of chin shields, first pair in contact, second pair not or but slightly

wider than first pair, separated by a single scale; legs moderately long, the adpressed hind leg reaches or fails slightly to reach elbow of foreleg; twenty-four lamellæ under fifth toe, thirty-two scale rows around body, each scale on back and side with either five or seven keels; belly scales smooth; anals somewhat enlarged; tail very slender, elongate.

Color in life.—Above iridescent olive-black, with bluish white to gray lines. There is a median black stripe beginning on parietals and extending to some distance on tail; this is bordered by two grayish white lines which also extend on tail; a dorsolateral yellowish stripe runs from snout along the superciliaries, and on the sides to some distance on the tail; another cream line runs along labials through auricular opening to groin; below this line, separated by a dark stripe, is another white line broken by the foreleg and continuing to groin; below this last line is only a trace of a dark line; belly greenish white; tail growing brownish toward middle; foreleg and hind leg with indistinct spots.

Measurements of the type of Mabuya bontocensis sp. nov.

	mm.
Total length	160
Snout to vent	60
Tail	100
Length of head	15
Width of head	9

There is little or no variation in the coloration. The interparietal is invariably small, never separating the parietals; in two specimens it is only partially distinct from the parietals; in the other specimens the parietals are injured, and the condition of the interparietal cannot be determined. The following table gives the variation in scale counts:

Scale counts in specimens of Mabuya bontocensis sp. nov.

No.	Locality.	Scale rows.	Superciliaries.	Lamellæ under fourth toe.
350	Baguio, Mountain Province	30	4	23-24
694	Subangan, Bontoc Subprovince	30	4	23-24
705	Near Bontoc, Bontoc Subprovince	30	4	23-24
722	do	30	4	24

Remarks.—This species belongs to the *Mabuya multicarinata* Gray group. It differs from that species in coloration and

markings and appears to be smaller. There are fewer superciliaries; the anterior loreal is much higher than the second one; the interparietal is much smaller, not separating parietals and partially fused with them.

The present species was found to occur from Baguio, along the Mountain Trail, to northern Kalinga. It is probably confined to the plateau and mountain region of northern Luzon. It is not uncommon, and specimens were seen moving about on the cliffs that border the trail.

In a previous work[10] I mention a young specimen collected in Baguio; this is No. 350, listed in the table.

Otosaurus cumingii Gray.

Otosaurus cumingii GRAY, Cat. Liz. (1845) 93; TAYLOR, Lizards of the Philippine Islands (1922) 163, pl. 13, fig. 2, and text fig. 16.

Three specimens of this large skink were collected; two on Calotcot, a small island in the Polillo group, and one on Mount Maquiling, Laguna Province, Luzon.

The Calotcot specimens were shot from forest trees, one specimen at an elevation of about 13 meters. Others were observed in trees. Nowhere else have I ever found this species in trees, as it is, in localities where I have previously collected it, terrestrial in habit and lives for the most part under rocks and in holes in the ground. It will be noted, from the table herewith given, that the Luzon specimen, like those from Bataan Province, Luzon,[11] has a much higher average of scale rows than have those from Calotcot and Mindanao. With larger series it may be possible to separate this form having the high scale count from the typical one.

Measurements and scale counts of Otosaurus cumingii Gray.

No.	Locality.	Length, snout to vent.	Tail.	Upper labials.	Lower labials.	Supra-oculars.	Lamellæ under fourth toe.	Scale rows.	Super-ciliaries.
		mm.	*mm.*						
197	Calotcot	135	220	8	8	8-9	27-29	52	16
198	do	134	[a] 174	9	8	7-8	27-79	54	16
1919	Los Baños	107	([b])	9	8	7	26	60	13-14

[a] Tail regenerated. [b] Tail broken and lost.

[10] Lizards of the Philippine Islands (1922) 153.

[11] Taylor, loc. cit. 165.

Sphenomorphus decipiens (Boulenger).

Lygosoma decipiens BOULENGER, Proc. Zool. Soc. London (1894) 734, pl. 49, fig. 3.

Sphenomorphus decipiens TAYLOR, Lizards of the Philippine Islands (1922) 176, pl. 15, fig. 2.

I collected specimens of this species in Kalinga, northern Luzon, and on Polillo Island. Good series were taken in each locality. The frenals are normal in specimens from both localities, and show no variation. The scale rows of the Kalinga specimens number thirty-four or thirty-six. A single specimen has numerous spots on the chin and throat.

The species appears to be common in the two localities mentioned. Specimens are encountered moving about through the forest or under leaves where they feed on small insects. The type locality is Isabela Province, northern Luzon.

Sphenomorphus curtirostris Taylor.

Sphenomorphus curtirostris TAYLOR, Philip. Journ. Sci. § D 10 (1915) 101; Lizards of the Philippine Islands (1922) 170, pl. 14, fig. 3, and text fig. 18.

A number of specimens belonging to this species was collected at Los Baños, and low on the sides of Mount Maquiling, Laguna Province. They agree very well with the type, which comes from central eastern Mindanao.

Each of the ten specimens agrees with the type in having the frenals normally broken into two parts and superimposed. The chin and throat in the males are blue-black, minutely dotted with white. This marking extends on the sides of the head and neck. There is a distinct white line above the tympanum from the eye to near the insertion of the arm. The species is not rare at low elevations on Maquiling.

Sphenomorphus atrigularis Stejneger.

Sphenomorphus atrigularis STEJNEGER, Proc. U. S. Nat. Mus. 34 (1908) 199, figs. 1 and 2; TAYLOR, Lizards of the Philippine Islands (1922) 196.

I have referred to this species a series of specimens collected at Zamboanga and Basilan. There are a number of differences between these and the type specimen, but they agree for the most part in color and marking and in most of the essential scale characters. Judging by Stejneger's figure, the head of the type appears somewhat lower than in my specimens, and the arrangement of the loreals is different, save in a single specimen.

The loreal elements in the small Philippine skinks are variable, and in this series of specimens practically no two can be found that are identical. Several have two well-defined loreals followed by two or three small superimposed preoculars; others have a large anterior loreal followed by two superimposed loreals; one specimen has a large anterior loreal separated from the upper preocular by the tip of the prefrontal scale. The size of the loreals varies also. Sometimes the anterior is larger, sometimes the posterior. The nasal varies in size. The dorsolateral black streak is rarely a distinct continuous line, but is usually a series of irregular spots; the light streak above this dark line, on the anterior part of the body, is almost invariably evident. The temporals are all small. There is practically no difference among the specimens in the scalation of the top of the head.

All female specimens seem to have the dark marking on the throat and chin wanting. Males have the throat deep blue-black. The brown color on the back varies from light yellow-brown to deep blackish brown.

Sixteen specimens were collected. They were found moving about through the forest.

Sphenomorphus steerei Stejneger.

Sphenomorphus steerei STEJNEGER, Proc. U. S. Nat. Mus. 34 (1908) 201, figs. 3 and 4; TAYLOR, Lizards of the Philippine Islands (1922) fig. 23.

I collected more than twenty-five specimens of this diminutive species about the base of Mount Maquiling, Luzon, and a single specimen on Polillo Island. Others were seen in the forest of Polillo, but they escaped capture. The species was obtained in southern Leyte by Lopez.

Sphenomorphus biparietalis Taylor.

Sphenomorphus biparietalis TAYLOR, Philip. Journ. Sci. § D 13 (1918) 249; Lizards of the Philippine Islands (1922) 177.

Thirty-five specimens of this diminutive species were collected on Jolo Island. All agree with the type in general conformation of the head scales and in coloration. In the type description I mention a specimen from Basilan and call attention to its different markings, broader head, and greater number of scale rows. I am convinced that this specimen represents a variation of *Sphenomorphus atrigularis* Stejneger. Unfortunately, the specimen is no longer at hand for direct comparison.

Specimens were taken under logs, leaves, and trash, and moving about in the forest. It is a common form on Jolo and the Sulu islands to the south.

Sphenomorphus stejnegeri sp. nov.

Type.—No. 16, E. H. Taylor collection; collected on Mount Banahao, Laguna Province, Luzon, May 30, 1920, by Edward H. Taylor.

Description of type.—Rostral visible above, forming a broad suture with frontonasal; latter much broader than deep, touching anterior frenal laterally; prefrontals broader than deep, broadly in contact; frontal much longer than broad, longer than its distance from tip of snout, not as broad as supraocular region; frontoparietal single, broader than deep; interparietal small, triangular; parietals large, forming a suture behind interparietal; a small nuchal scale on one side (may be abnormal and due to a fusion of two body scales); nostril in a single nasal; large anterior frenal, followed by two superimposed frenals, of which the lower is much the larger; two or three small preoculars; two rows of small irregular suboculars; eight superciliaries, the anterior large, touching frontal; four supraoculars, the last barely in contact with parietal, anterior separated from prefrontal; three pairs of small scales separate parietal and temporals from orbit; two inferior temporals small; three superior temporals much enlarged, the anterior largest, very broad, followed by two greatly elongated vertical temporals; scales following these also enlarged; an elongate temporal bordering parietal separates the two elongate scales from parietal; seven upper labials, fourth lowest, with two enlarged suboculars immediately above it; mental broader than rostral, followed by a broad deep postmental; three pairs of chin shields, the anterior pair in contact, second pair separated by a single scale, third pair by four scales; auricular opening large, the tympanum not deeply sunk; thirty-two scale rows around middle of body, scales on side very distinctly smaller than ventrals or dorsals; limbs moderately well developed, the adpressed limbs meeting on the side, fourth toe very much longer than third, with fourteen lamellæ on undersurface.

Color in life.—Above dark variegated brown with a median series of dark blackish spots separated by yellowish brown spots; a broad dark streak from eye to some distance on tail, edged above anteriorly by a very narrow yellow-brown line; the streak

is broadest and darkest on the side of the neck and above the foreleg; below this streak dirty flesh color, becoming pinkish on the belly; chin and throat with dim dusky flecks; top of head olive brown with dark scattered spots; loreal region spotted black; labials with dim yellowish spots; a yellowish streak from eye to above auricular opening below the dark streak; tail nearly uniform above, on sides with very indistinct minute markings of cream; underside pink.

Measurements of the type of Sphenomorphus stejnegeri sp. nov.

	mm.
Total length	66
Snout to vent	27
Snout to foreleg	10
Axilla to groin	14
Foreleg	9
Hind leg	6

Remarks.—In the character of the temporals this species differs from other Philippine species that have the undivided frontoparietal. The specimen is apparently immature, but I believe it is a diminutive species.

The single specimen, the type, was found on Mount Banahao, at an elevation of about 1,000 meters. The species is named for Dr. Leonhard Stejneger, the eminent herpetologist of the United States National Museum, Washington, D. C.

Sphenomorphus fasciatus (Gray).

Hinulia fasciata GRAY, Cat. Liz. (1845) pl. 15, fig. 2.

Sphenomorphus fasciatus TAYLOR, Lizards of the Philippine Islands (1922) 188, pl. 12, fig. 3.

I found two eggs of this species, containing fully developed embryos, on September 24, 1920, in a rotten log near Pasananka, Zamboanga. The embryos have the belly tinged with salmon; above they are black, and the dotted transverse bars are milk white; the top of the head is reddish.

An adult was taken September 29, 1920, not far from where the eggs were found. The belly is yellow anteriorly and pink to orange posteriorly. The transverse bars on the body are yellow-brown, on the tail milk white. An adult male specimen was collected on the seashore at Isabela, Basilan. The bars above on the body are golden brown, the throat is flesh color. A dull yellow wash covers the belly, and pink areas are present under limbs and about anus.

I believe this species is confined to Mindanao and neighboring islands.

Sphenomorphus variegatus (Peters).

Lygosoma (Hinulia) variegatum PETERS, Mon. Berl. Ak. (1867) 20.
Sphenomorphus variegatus TAYLOR, Lizards of the Philippine Islands (1922) 184.

This species was collected at Zamboanga; at Port Holland and Abung-abung, Basilan; and at various localities on Jolo. The species occurs commonly in Mindanao and Sulu. I have stated [12] that the type locality is the Philippines. This is only a supposition, since Peters does not specifically so state and in his paper [13] treats certain species that are not Philippine. It is, however, very probably the type locality, and it would be a matter for wonder if the species was not collected by Semper, who collected for Peters, since it is very common wherever it occurs in the Islands.

No specimen has yet been collected on Palawan, although it occurs in Borneo. I collected it on Cagayan Sulu, a small island north of Borneo. It probably occurs also on Leyte and Samar, but not farther north.

Leiolopisma pulchellum (Gray).

Lipinia pulchella GRAY, Cat. Liz. (1845) 84.
Leiolopisma pulchellum TAYLOR, Lizards of the Philippine Islands (1922) 212, pl. 15, fig. 5.

Specimens of this diminutive species were collected on Polillo and on Mount Maquiling, Laguna Province, Luzon. The specimens agree with each other very well in color and markings, but differ in certain important scale characters.

Table of measurements and scale counts of Leiolopisma pulchellum (Gray).

No.	Locality.	Collector.	Length, snout to vent.	Supra-oculars.	Scale rows.	Lamellæ under longest toe.
			mm.			
278	Polillo	E. H. Taylor	43	5	24	24
278A	do	do	40	5	22	24
279	do	do	42	5	24	23
279A	do	do	36	5	24	23
279B	do	do	40	4	24	25
281	do	do	38	5	24	25
283	do	do	44	5	24	22
284	do	do	40	5	24	22
383	do	do	40	4	24	24
1914	Los Baños	do	38	4	20	24
1915	do	do	40	4	22	23
1916	do	do	42	4	22	24

[12] Loc. cit. [13] Loc. cit.

The table shows the principal variations. The number of supraoculars is variable. The type has only four supraoculars.[14]

In the type the hind leg is said to reach the axilla. I found this to be the case in only very young specimens. None of the specimens listed here has the toes of the hind leg reaching much beyond the elbow of the adpressed foreleg. All the specimens agree with the type in color.

Tropidophorus grayi Günther.

Tropidophorus grayi GÜNTHER, Proc. Zool. Soc. London. (1861) 189; TAYLOR, Lizards of the Philippine Islands (1922) 236.

This species was found to be very common on Polillo Island, but is apparently absent from Calotcot Island, lying east of Polillo. The latter condition is probably due to the fact that there is no standing or running water on the island. A few specimens were obtained on Mount Maquiling and on Mount Mariveles. Gregorio Alforo y Lopez collected a single specimen of the species at Cabalian, Leyte.

Measurements and scale counts of Tropidophorus grayi Günther.

No.	Locality.	Collector.	Scale rows.	Lamellæ under fourth toe.
335	Polillo	E. H. Taylor	28	17
1886	Los Baños	do	26	17
0000	Leyte	G. Lopez	26	22

One small specimen has five instead of four labials preceding the large subocular labial on one side. The same specimen also has each frontoparietal broken into two scales. The Leyte specimen differs from the specimens from Polillo and Los Baños in having slightly longer toes with five more lamellæ than the average for the more northern specimens. The height of the spiny keels on the neck and back is distinctly greater.

[14] Boulenger, Cat. Liz. Brit. Mus. ed. 2, 3 (1887) 254, states that the supraoculars are 5. The drawing, pl. 17, fig. 1, leads me to believe that the "first very small" supraocular should be regarded as a superciliary.

Tropidophorus rivularis Taylor.

Tropidophorus rivularis TAYLOR, Philip. Journ. Sci. § D 10 (1915) 106; Lizards of the Philippine Islands (1922) 240, pl. 21, fig. 2.

A large series of this species was collected along the Tumugao River, Zamboanga, and at Abung-abung, Basilan. The lizards were invariably found along small rivers or brooks, usually under partly submerged logs or stones. They generally entered the water to escape pursuit.

Among the lot of about fifty specimens are numerous large females containing embryos. One female contains five embryos which measure approximately 90 millimeters in length, with a snout-to-vent measurement of 35 millimeters. The longest adult specimen in the collection (No. 1081 from Zamboanga) measures 260 millimeters in length; snout to vent, 108.

Most of the older specimens have the throat coal black with a few scattered white spots, and the belly a deep red-orange. Above they are dull blackish to olive, variegated with dim traces of transverse bars. This species and the recently described *Tropidophorus stejnegeri* are closely related, but distinct. Both were taken in the same general localities, save that *T. stejnegeri* was always found in the forest and mountains away from water.

Brachymeles eleræ Taylor.

Brachymeles eleræ TAYLOR, Philip. Journ. Sci. § D 12 (1917) 273, figs. 4 and 5; Lizards of the Philippine Islands (1922) 254.

Two specimens were collected at Balbalin, Kalinga Subprovince, which I have referred to this species. They agree with the type specimen in general. However, the internasals appear to be somewhat larger, and the prefrontals are narrowly in contact, separating the prefrontal from the frontal; the frontoparietals are also in contact; the arrangement of the chin shields is the same as in the cotype.[15]

The preanals appear to be somewhat smaller than in the type. One of the specimens has no digits on one hind leg, due to an old injury. The length of the longest toe is about 0.5 millimeter; of the longest finger about 0.25 millimeter; the distance between the snout and the insertion of the foreleg is contained in the axilla-to-groin distance three and seven-tenths times; the length of the hind leg is contained in the axilla-to-groin distance nine and four-tenths times.

[15] Taylor, loc. cit. fig. 5.

Measurements of Brachymeles eleræ Taylor.

	No. 855. mm.	No. 856. mm.
Total length (tail regenerated)	111	[a] 73
Snout to foreleg	14	16
Snout to vent	69	71.5
Axilla to groin	52	55
Foreleg	3.3	3.4
Hind leg	5.5	5.6
Width of head	6	6.4
Snout to posterior part of parietal	7	7

[a] Tail wanting.

Variation.—The second specimen, taken in the same immediate locality, is a female containing embryos. No variation of importance is noted.

Remarks.—The type of this species is now in the Santo Tomas Museum, Manila. The type locality is no longer known.

At Balbalin, Kalinga Subprovince, no other species of *Brachymeles* were found, but in the low country around Payao, Ifugao Subprovince, two species, *B. boulengeri* and *B. burksi*, were collected.

One species of the genus, *Brachymeles bicolor*, is as yet without definite locality records. It is probable, however, that it is also a Luzon species.

SNAKES

Typhlops braminus (Daudin).

Eryx braminus DAUDIN, Hist. Nat. Rept. 7 (1803) 279.
Typhlops braminus TAYLOR, Snakes of the Philippine Islands (1922) 50.

Specimens of this species were obtained in Polillo, Los Baños, Basilan, and Jolo. The specimens are typical. The species is apparently very common on Jolo. It appears to be rare in other localities.

Natrix auriculata (Günther).

Tropidonotus auriculatus GÜNTHER, Cat. Col. Snakes (1858) 80.
Natrix auriculata TAYLOR, Snakes of the Philippine Islands (1922) 89.

This species was collected only in Zamboanga and Basilan. In both localities it was found along streams and rivers, in moist situations.

There are several specimens in the British Museum listed by Boulenger from Pasananka. Most of my Zamboanga specimens are from near the same locality. I note no differences of any importance between the specimens from this locality and those

from Basilan, save that several of the Zamboanga specimens (Nos. 1078, 1079A, 1095, 1096) have the preocular broken into two parts, and a few have a single anterior temporal. Nos. 1079A and 1045 from Zamboanga and Nos. 1379 and 1586 from Basilan have single anterior temporals. One or two more specimens show this character on one side only. The largest and smallest among twenty-one specimens in the collection measure as follows: No. 1097, Zamboanga, total length, 560 millimeters; tail, 170. No. 1101, Zamboanga, total length, 149 millimeters; tail, 41. Variations in color and markings are due chiefly to age. This is the smallest *Natrix* in the Philippines.

Cyclocorus nuchalis sp. nov. Plate 3, figs. 1, 2.

Type.—No. 1428, E. H. Taylor collection; collected at Pasananka, Zamboanga, September 30, 1920, by Edward H. Taylor.

Description of type.—(Male.) Rostral very much broader than high, not or very narrowly visible from above; internasals small, broader than long; prefrontals moderately large, in contact for at least three-fourths of their length, rounded behind, much broader than long; frontal shield-shaped, the sides nearly parallel, twice as long as wide, only slightly wider than supraocular; parietals one and one-fourth times as long as wide, touching both postoculars and bordered by three temporals, their mutual suture equal to the length of the frontal; nasal apparently partially divided on one side, wholly on the other; loreal very small, slightly larger than lower preocular; two preoculars, the upper three times as large as the lower; two postoculars subequal in size; one anterior temporal, followed by two, then three temporals; seven supralabials, third and fourth entering orbit; diameter of eye distinctly greater than distance of eye to edge of mouth; eight lower labials, last very small, the three anterior ones touching anterior chin shields; posterior chin shields longer than anterior, in contact the greater part of their length; scales in seventeen rows without or with only very dim apical pits; ventrals, 133; anal, single; subcaudals, 58.

Color in life.—Dull brownish on anterior part of body, dark black-brown on posterior part. A median black stripe begins on neck and continues to tip of tail, very dimly evident on anterior part of body; a broad black spot on neck beginning three scales behind parietals; on the latter third of body and tail a black stripe on either side, not or but dimly visible on middle third; head with a black parietal spot which connects

with a dark area between eyes; a dark area on tip of snout; a dark line from eye to near dark nuchal spot; a spot below eye and small spots on anterior upper labial; upper labials generally lavender; lower labials spotted black and white; prominent black spots on outer edges of anterior ventrals; outer edges of ventrals dark, growing black posteriorly; median part of ventrals with small spots, not triangular in shape. No scattered spots under tail.

Measurements of the type of Cyclocorus nuchalis sp. nov.

	mm.
Total length	444
Tail	118
Width of head	16
Length of head	17

Variation.—A second specimen in my collection from Abungabung, Basilan, agrees with the type in essential details; the fourth lower labial, however, touches the first pair of chin shields, and the posterior chin shields are slightly shorter and separated for the greater part of their length; a row of cream dots can be traced on the sides, touching the fourth and fifth scale rows, the scales bearing dots, separated by two vertical scale rows. The posterior part of the body is less black and the lateral dark lines are very dim. The lateral light dots are discernible also in the type on very close observation; ventrals, 144; subcaudals, 45; anal, single.

Remarks.—This species differs from *Cyclororus lineatus* (Reinhardt) in having seven instead of eight upper labials; in having the third and fourth instead of the third, fourth, and fifth upper labials entering the orbit; in having shorter and wider parietals; and in having larger eyes.

In my monograph on Philippine snakes [16] I list a series of *Cyclocorus lineatus* from Mindanao. The specimens are not at hand for study at present, but they have a lower number of ventral scales and a higher average of subcaudals than do species occurring in northern islands; three instead of four or five lower labials is the usual number that border the anterior chin shields and the temporal formula is 1 + 2. The present species has the same temporal formula as the Mindanao specimens and there are three or four labials bordering the first chin shields. I strongly suspect that the group of specimens

[16] Snakes of the Philippine Islands (1922) 108.

listed from Mindanao should be regarded as distinct from *C. lineatus*, and perhaps joined to this species.

The color markings on the head are very different from those in *Cyclocorus lineatus*. I collected only the two specimens.

There is a single young specimen in the collection of the Bureau of Science, without locality data, which agrees with the type in general details. It differs slightly in color and in that there is a distinct band, between the eyes, connected with the nuchal spot by an irregularly edged line; the second chin shields are shorter than the anterior; two labials enter the eye, and there are but seven upper labials; ventrals, 130; subcaudals, 59; the median dark stripe is bordered by two broad lighter areas.

Cyclocorus lineatus (Reinhardt).

Lycodon lineatus REINHARDT, Kongl. Danske Vid. Selsk. Afhandl. 10 (1843) 241, pl. 1, figs. 7–9.

Cyclocorus lineatus TAYLOR, Snakes of the Philippine Islands (1922) 106.

In my treatment of this species I apparently confused certain specimens of *Cyclocorus lineatus* with *C. nuchalis* sp. nov., the species herein described. The young specimen mentioned[17] is undoubtedly a specimen of the latter species, as are probably certain others listed in the table;[18] at least, if not identical, I believe they must represent a third species characterized by the temporal formula 1 + 2, the three lower labials touching the chin shields, the three labials entering the eye, and the tail being longer than in *C. lineatus*. They are probably more closely related to *C. nuchalis* than to *C. lineatus*.

Unfortunately, the specimens are in the Carnegie Museum, and at present not available to me for study. In consequence I hesitate to name the eastern Mindanao specimens.

The characteristic marking on the head of true *Cyclocorus lineatus* takes the form of a line from the frontal to the neck that is widened between the eyes and forks into three indistinct branches which continue as distinct or broken lines to the tip of the snout; the nuchal band is a V- or a U-shaped mark which crosses the median line five or six scales behind the parietals, and the branches run forward to the posterior temporals where they are joined by two dark lines that begin at the eye. The light line on the labials usually turns and goes

[17] Op. cit. 108.

[18] Loc. cit.

from the angle of the mouth up to the median dark line behind the U-shaped mark. The three or four scale rows on either side of the median dark stripe vary from brownish cream in the young to dark brown in the adults; in many specimens the stripes can scarcely be distinguished from the lateral coloration which is a purplish or lavender-brown.

Only one specimen in the Bureau of Science collection from southern Negros has a single anterior temporal, but the second temporal is separated from the postoculars by only a very short distance. A second specimen from the same locality has the temporal formula 2 + 2, which is the normal one. Fourteen specimens in my collection are from the following localities: Balbalin, Kalinga Subprovince; Polillo Island; Los Baños, Laguna Province; and Oriental Negros.

Hurria rynchops (Schneider).

Hydrus rynchops SCHNEIDER, Hist. Amph. 1 (1799) 246.
Hurria rynchops TAYLOR, Snakes of the Philippine Islands (1922) 111.

There appear to be two varieties of this species, characterized by the presence of two or three prefrontals. The specimens in my own collection and in that of the Bureau of Science vary as follows:

Specimens from Bantayan (29), Negros (2), Jolo (2), Leyte (1) have only two prefrontals, with the anterior labial not broken, leaving a "subnasal" scale.

Specimens from Los Baños (2), Luzon (5), Manila (4), Polillo (1), Camiguin, Babuyan Islands (1) have the anterior labial broken, leaving a "subnasal," a median prefrontal, making a total of three prefrontals. Save for this character I have not discerned any stable character which is constant throughout the two groups of specimens. There are differences in color, but these are not constant.

With my limited material I have hesitated to name the Luzon form. If the variation occurs throughout the island, it would be worthy of designation by name. If Gray's *Cerberus unicolor* described from the Philippines belongs to this form, that name will be applied to the form. The name would fit the coloration of the Luzon form. However, my specimens from Jolo having only two prefrontals are also uniformly colored. So it is difficult to say to which of the above-mentioned groups *C. unicolor* should be assigned.

Hurria microlepis (Boulenger).

Cerberus microlepis BOULENGER, Cat. Snakes. Brit. Mus. 3 (1896) 18, pl. 2, fig. 2.

Hurria microlepis TAYLOR, Snakes of the Philippine Islands (1922) 114, pl. 6, figs. 1–3.

I have been able to examine a series of specimens belonging to this species collected in or near Lake Buhi, Ambos Camarines Province, southern Luzon. The specimens agree fairly well with Boulenger's description and figure. There is, however, considerable variation evident in the four specimens from the same immediate locality. The scale rows vary from 27 to 33. In two specimens the prefrontals touch the nasals, in two they do not. Ventrals vary between 163 and 168, and subcaudals between 60 and 67.

The most important character, it seems to me, and one which is not mentioned in the type description, is the character of the scales. Each scale has numerous small pits or rugose spots; the scales of the head and neck are thickly covered with these, while the costal scales have them arranged around the outer posterior borders. A small low keel is evident on all but the two or three outer costal scale rows.

The ventral scales have two or three very irregular rows of pustules, or pits, crossing their middle transversely. In coloration there is much variation. The ground color varies between gray and brown, with numerous irregularly placed black spots; there is a dark streak along the canthi, passing through the eye to the angle of the jaw or continuing some distance on the neck; three black stripes that begin in the occipital region continue some distance on the neck. These neck markings may be very distinct or almost wanting; the outer three costal scale rows are cream colored without markings, or heavily spotted. The belly is marked by a narrow or a broad irregular longitudinal stripe, or spotted and mottled irregularly.

In my work on Philippine snakes [19] I mention the head of a specimen supposed to be of this species, from Camiguin, Babuyan Islands. I have compared it with these specimens of *Hurria microlepis* and am convinced that it does not belong to that species.

[19] Snakes of the Philippine Islands (1922) 114.

Measurements and scale counts of Hurria microlepis (Boulenger).

No.	Collection.	Sex.	Length.	Tail.	Ventrals.	Subcaudals.	Scale rows.	
							Neck.	Body.
			mm.	*mm.*				
2082	E. H. Taylor	♂	810	163	166	67	27	27
2083	do	♂	760	153	163	65	29	29
852	Bureau of Science	♂	800	140	166	62	30	31
855	do	♂	810	150	168	60	31	33

No.	Upper labials.[a]	Lower labials.	Labials touch first chin shields.	Labials touch loreals.	Prefrontals.	Prefrontal touches nasal.	Suboculars.	Preoculars.	Postoculars.
2082	9-10	11	4	4	2	No	2-1	1	1
2083	8	10-11	4	3, 4	2	No	2	1-2	2
852	8	11-10	3	3	2	Yes	3	1	1
855	8	10	4	3	2	Yes	3-2	1	2

[a] Small scales bordering mouth angle not counted.

Holarchus ancorus (Girard).

Xenodon ancorus GIRARD, Proc. Acad. Nat. Sci. Philadelphia (1857) 182.

Holarchus ancorus TAYLOR, Snakes of the Philippine Islands (1922) 140.

Measurements and scale counts of Holarchus ancorus (Girard).

No.	Locality.	Collector.	Age or sex.	Length.	Tail.	Ventrals.	Subcaudals.
				mm.	*mm.*		
934	Balbalin, Kalinga	E. H. Taylor	♂	520	85	162	43
935	do	do	♂	435	77	155	41
36	Los Baños, Laguna	do	♂	455	73	162	40
37	do	do	yg	182	25	165	43
38	do	do	yg	285	46	159	45

No.	Anals.	Spots.	Upper labials.	Lower labials.	Labials enter eye.	Labials touch chin shields.	Temporals.
934	1	21	7	7	3 and 4	4	1+2
935	1	18	7	7	3 and 4	4	1+2
36	1	19	7	6-7	3 and 4	3	1+2
37	1	16	7	8	4	4	1+2
38	(?)	19	7	7	4	4	1+2

Five specimens are in the collection; two were collected at Balbalin, Kalinga Subprovince, and three are from Los Baños, Laguna Province.

The preoculars are normal in all save No. 38, which has two preoculars instead of one on the left side.

The three adult specimens are dark lavender with a median salmon line and purplish crossbars. The belly is pink. The crossbars are lavender to purple, black-edged. No. 934 has considerable dark marking on the posterior half of belly and under tail.

Calamaria polillensis sp. nov.

Type.—No. 341A, E. H. Taylor collection; collected at Polillo, Polillo Island, July, 1921, by Edward H. Taylor.

Description of type.—Rostral higher than broad, well visible above, the part visible triangular in shape; prefrontals broader than long, pointed anteriorly, touching two labials laterally; frontal one and three-fourths times as long as broad, at least twice as wide as supraoculars and more than one and three-fourths times as long; parietals longer than wide, only a little longer than frontal; one small scale inserted between parietals at posterior part; parietals followed by two transversely widened scales, separated by a single scale; nasal triangular, minute; six upper labials, third and fourth entering eye; a small elongated preocular; one postocular; one posterior temporal bordering parietal; scales in 13 rows; eye small, rather longer than high, higher than its distance from mouth; ventrals, 131; subcaudals, 19.

Color in life.—Above olive, growing rather brownish on the anterior part of body, each scale edged with a darker color; head yellowish brown; the supraoculars darker; outer edge of parietals whitish with an indistinct darker marking; labials yellow save for a very slight edge of brown above; the yellow color almost forms a band behind parietals; on neck a brown spot, each of the outer scales of those that form the spot with a black area; this followed by a yellow ring about the width of two transverse scale rows; the scales following the band each with a black spot; none or only a very few dark spots scattered on body; outer scale row with cream spots; chin, throat, and anterior ventrals immaculate yellow; the following ventrals with a few scattered dots which form very indistinct transverse lines on some ventrals; a zigzag dark line on subcaudals.

Measurements of the type of Calamaria polillensis sp. nov.

	mm.
Total length	180
Snout to vent	162
Tail	18
Width of head	4.5
Length of head	0.8

Variation.—The four cotypes are females and differ from the type in a higher average of ventrals (145 to 149) and a lower average of subcaudals (16 or 17). The females have the ventrals, beginning at the twelfth, each with a dark bar. The body is more strongly marked with blackish dots than in the type. These dots are not arranged in longitudinal lines. There is a suggestion of a third neck band on some of the specimens. The scale counts of the four cotypes are: No. 341B, ventrals, 149; subcaudals, 16; No. 341C, ventrals, 145; subcaudals, 17; No. 341D, ventrals, 145; subcaudals, 16; No. 341E, ventrals, 145; subcaudals, 16.

Remarks.—This species is related to *Calamaria hollandi* sp. nov. and to *C. gervaisii* Duméril and Bibron. From the former it differs in the shape of the rostral, in the presence of dark bars on the ventrals, and in the color and markings on the head; the counts of ventrals and subcaudals are nearly the same, there being only three less ventrals and two more subcaudals.

From *Calamaria gervaisii* it differs in lower ventral and subcaudal counts, in the presence of the neck ring, and in the different color and markings. From *C. tropica* it differs in the absence of the loreal scale.

The specimens were collected under rubbish in the Old Catholic Church within the walled town of Polillo. The church, which has suffered from earthquake, has a dirt floor. Aside from the *Calamaria,* I collected in this church three species of amphibia; five other species of snakes; eight species of birds; and four mammals, one of which was a wildcat, *Viverra tangalang* Gray. The church is still used as a place of worship.

Calamaria hollandi sp. nov.

Type.—No 1255, E. H. Taylor collection; collected at Port Holland, Basilan, October, 1920, by E. H. Taylor.

Description of type.—Rostral about as broad as high, only a small portion visible above; prefrontals a little broader than long; frontal one and a half times as long as broad, about

twice as broad as supraocular and much longer; parietals longer than frontal, much longer than broad; scales bordering parietals enlarged, separated behind parietals by a small scale inserted between parietals at posterior part; nostril in a single very small nasal; a single narrow preocular, three times as long as wide; a small postocular a little higher than wide; five labials, last very large, third and fourth entering orbit; first and second labials touch prefrontal, second and third touch preocular, fourth and fifth touch postocular; one large posterior temporal; mental small, about as wide as rostral at its base; anterior chin shields very large, touching mental and three lower labials; second pair of chin shields much narrower and about two-thirds the length of anterior pair, separated save in anterior part by a single scale, separated from ventrals by three small scales; five lower labials, fifth separated from first ventral by four scales; scales smooth, in 13 rows; ventrals, 134; anal, single; subcaudals, 17; tail ending in a rather sharp point.

Color in life.—Above olive-brown with the sutures between scales rather darker, and three broken rows of dark dots, one on the median row, and one on the row third from the median; the two scale rows below that bearing the dark dots have small cream-white dots separated by brown coloring; the outer scale row has an unbroken white line on the anterior part of body and on the latter half each scale has a white dot; a brownish line borders the edge of the ventrals; belly and underside of tail immaculate; head almost uniform black-brown; heavy black spots on the labial sutures and on fifth labial; lower labials with black spots; a black-edged cream band crosses neck, separated from parietals by six scale rows.

Measurements of Calamaria hollandi sp. nov.

	mm.
Total length	175
Snout to vent	160
Tail	15
Width of head	4.5
Length of head	7

Remarks.—A single specimen was obtained. In the very low number of ventrals the species is apparently related to *Calamaria polillensis* sp. nov. and *C. joloensis* Taylor. The scale counts are almost identical with those of *C. polillensis*, but *C. hollandi* differs in the size of the rostral and its relation to the prefrontals. In *C. polillensis* a large part of the scale, triangular in form, is visible above. The markings are very dif-

ferent. From *C. joloensis* it differs in a higher number of ventrals and subcaudals, in color, and in markings.

The species is named for Mr. Guy Holland, who facilitated my collecting on Basilan Island, and to whom I am indebted for numerous courtesies.

Boiga schultzei sp. nov. Plate 3, fig. 3.

Type.—Unnumbered specimen in the collection of W. Schultze, Manila; collected in Palawan by C. M. Weber.

Description of type.—Rostral visible above as a narrow line, one and one-fourth times as wide as high; internasals about as broad as long; prefrontals very much broader than long, bent down over side of snout, the suture between them one and one-half times as long as that between internasals; frontal a little longer than broad, equal in length to its distance from rostral; parietals a little broader than long, followed by a single enlarged median scale; supraoculars a little longer than frontal, but narrower; nostril very large, pierced in a single large nasal; loreal small, distinct, longer than high; preocular three times as high as wide; two postoculars; two anterior temporals followed by three posterior; seven upper labials, third and fourth entering eye, third much elongate, fifth highest; mental triangular, as wide as rostral; ten lower labials, first five touching first pair of chin shields; first pair of chin shields broader but shorter than second pair; six rows of scales between posterior lower labials and ventrals; eye large, its diameter equal to its distance to end of snout; ventrals, 265; subcaudals, 140; anal, single; scales in 19 rows.

Color in alcohol.—Grayish, the entire upper and lower surface strongly powdered with very small black dots; body traversed with seventy-six darker blotches, each blotch with an indistinct darker transverse bar, the interspaces rather yellowish; bars do not extend on belly; bars on tail very indistinct; two well-defined dark lines on sides of belly; throat and chin cream; no dark line behind eye; head with minute black dots; low on sides is an inconspicuous row of yellowish cream spots.

Measurements of the type of Boiga schultzei sp. nov.

	mm.
Total length	1,410
Snout to vent	1,040
Tail	370
Length of head	13
Width of head	20

Variation.—There is a single cotype in my collection presented to me by Mr. W. Schultze. It agrees with the type in scalation of the head, save that the second labial is broken on the right side, making 8 upper labials on that side. The color in alcohol is light yellowish brown with 76 very narrow dark transverse bars. There are also 29 indistinct bars on the tail. There are 264 ventrals and 146 subcaudals. The specimen is a young one, collected by C. M. Weber in Palawan.

Remarks.—The species is related to *Boiga drapezi* and *B. angulata* (Peters). From the former it differs in having two instead of three labials entering the orbit; there are seven instead of eight upper labials; there is a well-developed loreal present.

From *Boiga angulata* the species differs in the number of labials and in the number of these entering the eye; in the character of the markings, particularly the very much larger number of bars on the back which do not cross the belly; and in the presence of the strongly defined lines on the belly.

I take pleasure in naming the species for Mr. Schultze, who is an entomologist of note and has made extensive herpetological collections in the Islands.

Boiga cynodon (Boie).

Dipsas cynodon BOIE, Isis (1827) 559.
Boiga cynodon TAYLOR, Snakes of the Philippine Islands (1922) 206.

I collected a single specimen of this species at Abung-abung, Basilan, but failed to find it elsewhere. Mr. Otto Pflueger, of the Forestry School, at Los Baños, Laguna Province, presented me with two young specimens which were collected low on Mount Maquiling. I purchased from a curio dealer in Manila a young specimen which probably was collected in Palawan or Balabac, since the jar in which it was obtained contained only species that occur in Palawan, several of which are confined to that island in the Philippines.

The Basilan specimen was killed by a Yakan, after it had entered his house at night. He had thrown the specimen away; when I obtained it in the morning ants had devoured much of the body. Consequently only the head was kept. It is uniform fawn color without any trace of marking.

I have recorded a specimen of this color from Polillo.[20]

The ventral and subcaudal scale counts are higher for Palawan specimens than the average for those from the eastern

[20] Loc. cit.

Philippines. The species varies so greatly in color and marking that it is difficult to find two specimens marked in the same manner.

The Basilan specimen has the preoculars in contact with the frontal, which is an unusual variation. In younger specimens the eye is only a little less than the length of the snout.

Measurements and scale counts of Boiga cynodon (Boie).

No.	Locality.	Sex.	Length.	Tail.	Ventrals.	Subcaudals.	Upper labials.
			mm.	*mm.*			
1461	Basilan	(?)	(?)	(?)	(?)	(?)	9
2210	Palawan?	♂	1025	240	269	150	9
2209	Los Baños	♀	833	180	275	139	9
2208	do	♀	732	150	259	132	9-10
(?)	Palawan [a]	yg	643	153	273	154	9

No.	Lower labials.	Labials enter eye.	Labials touch chin shields.	Scale rows.	Diameter of eye.	Length of snout.	Bars on body.
					mm.	*mm.*	
1461	15	3, 4, 5	(?)	23	8	11	
2210	14	3, 4, 5	5	23	5	8	41
2209	13-14	3, 4, 5	4	23	5.5	6	37
2208	13-14	3, 4, 5	5	23	5	6	33
(?)	13-15	3, 4, 5	5	23	4.5	6	43

[a] In the collection of W. Schultze, Manila.

Laticauda semifasciata (Reinwardt).

Platurus semifasciatus REINWARDT, in Schlegel, Phys. Serp. 2 (1837) 516.

Laticauda semifasciata TAYLOR, Snakes of the Philippine Islands (1922) 234.

This species was included in the Philippine fauna on the strength of a specimen preserved in Silliman Institute, Dumaguete, Oriental Negros. I mentioned this specimen previously [21] but had not examined the specimen carefully. I have since had an opportunity to study the specimen, thanks to the authorities of that institution. The specimen measures 1,600 millimeters; tail, 155. The color (preserved in formalin) is brown,

[21] Loc. cit.

with the scales edged with deeper brown and encircled by forty rings, grayish white on back and sides, and dim silver gray on belly. The bars are narrowed to one or two scale rows above, each separated by five scale rows. The scales are in twenty-five rows.

The anterior head scales are badly broken. There are two scales between the nasals bordering the rostral; two normal internasals; four prefrontals of which only three border the frontal; the outer one on the right side is broken into four scales. The nasal is broken into two parts, the posterior very small; one preocular is present; the frontal is nearly triangular; there are two postoculars; two anterior temporals, four posterior; seven upper labials, the third and fourth entering eye; eight lower labials; mental very small; first pair of chin shields large, broadly in contact; the second pair is widely separated by a large scale; a large scale separates the second pair from the lower labials; ventrals, 20; subcaudals, about 33 (anal region badly injured); first ventral separated from chin shields by eight scale rows.

Two living specimens of this species were obtained from a Japanese fisherman, who captured them at Olongapo Naval Station on the Zambales coast of Luzon. They are at present kept alive in the Aquarium of the Bureau of Science.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Rana woodworthi* sp. nov. Photograph of type, natural size. The specimen is in normal condition save that the tip of the snout has been pressed down.

2. *Rana woodworthi* sp. nov. Photograph of a young cotype specimen. Compare with a young specimen of *Rana magna* (fig. 3) slightly enlarged.

3. *Rana magna* Stejneger. Photograph of a young specimen from the same locality as *Rana woodworthi*, fig. 2. Slightly enlarged.

PLATE 2

FIG. 1. *Rana acanthi* sp. nov. Photograph of a specimen from Busuanga (chosen instead of type since it is in better condition).

2. *Rana micrixalus* sp. nov. Photograph of a cotype specimen. Slightly enlarged.

3. *Rana micrixalus* sp. nov. Photograph of the type specimen. Slightly enlarged.

PLATE 3

FIG. 1. *Cyclocorus nuchalis* sp. nov. Drawing of head of type, lateral view. $\times 2$.

2. *Cyclocorus nuchalis* sp. nov. Drawing of head of type, dorsal view. $\times 2$.

3. *Boiga schultzei* sp. nov. Drawing of head of type, lateral view. $\times 2$.

4. *Ichthyophis glandulosus* sp. nov. Drawing of head of type, lateral view. $\times 3$.

5. *Ichthyophis glandulosus* sp. nov. Drawing of head of type, ventral view. $\times 3$.

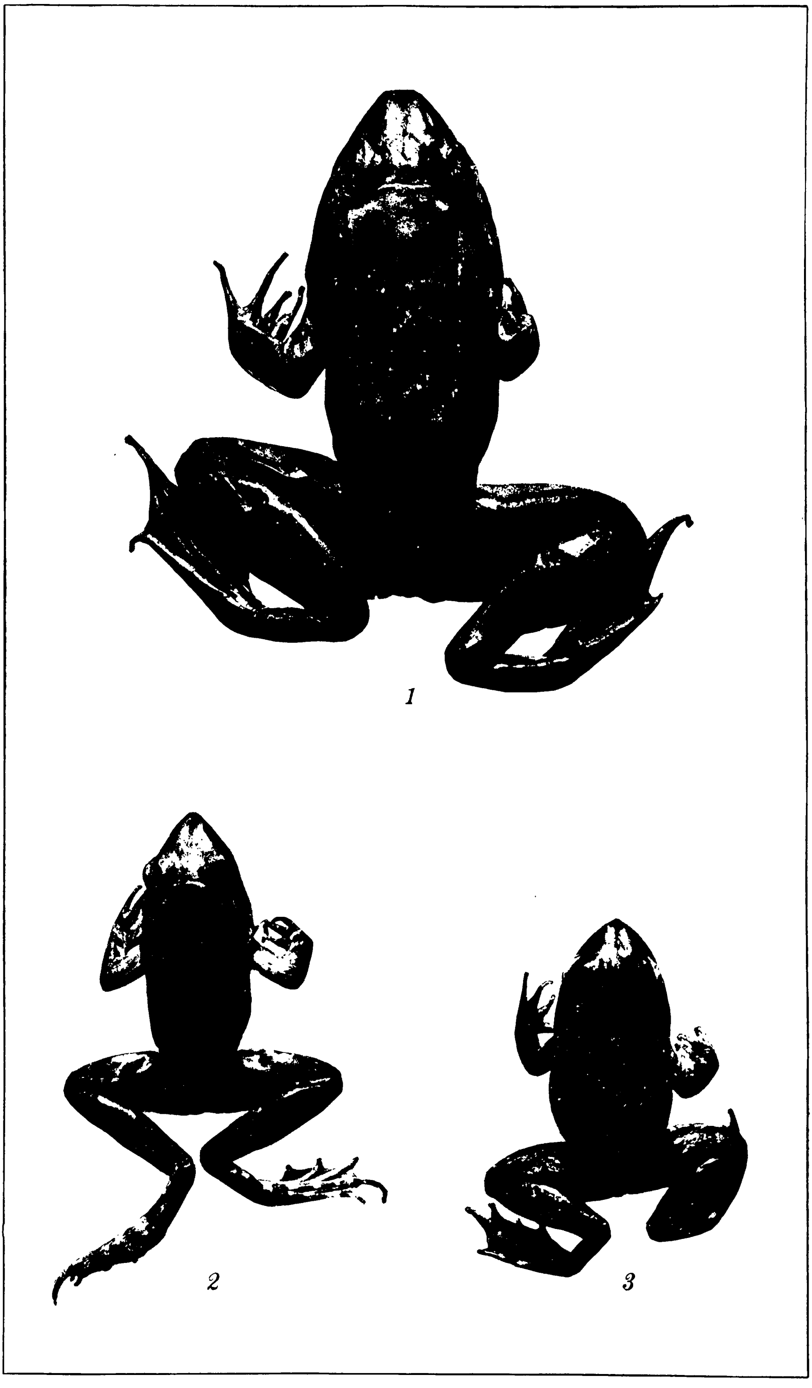

PLATE 1.

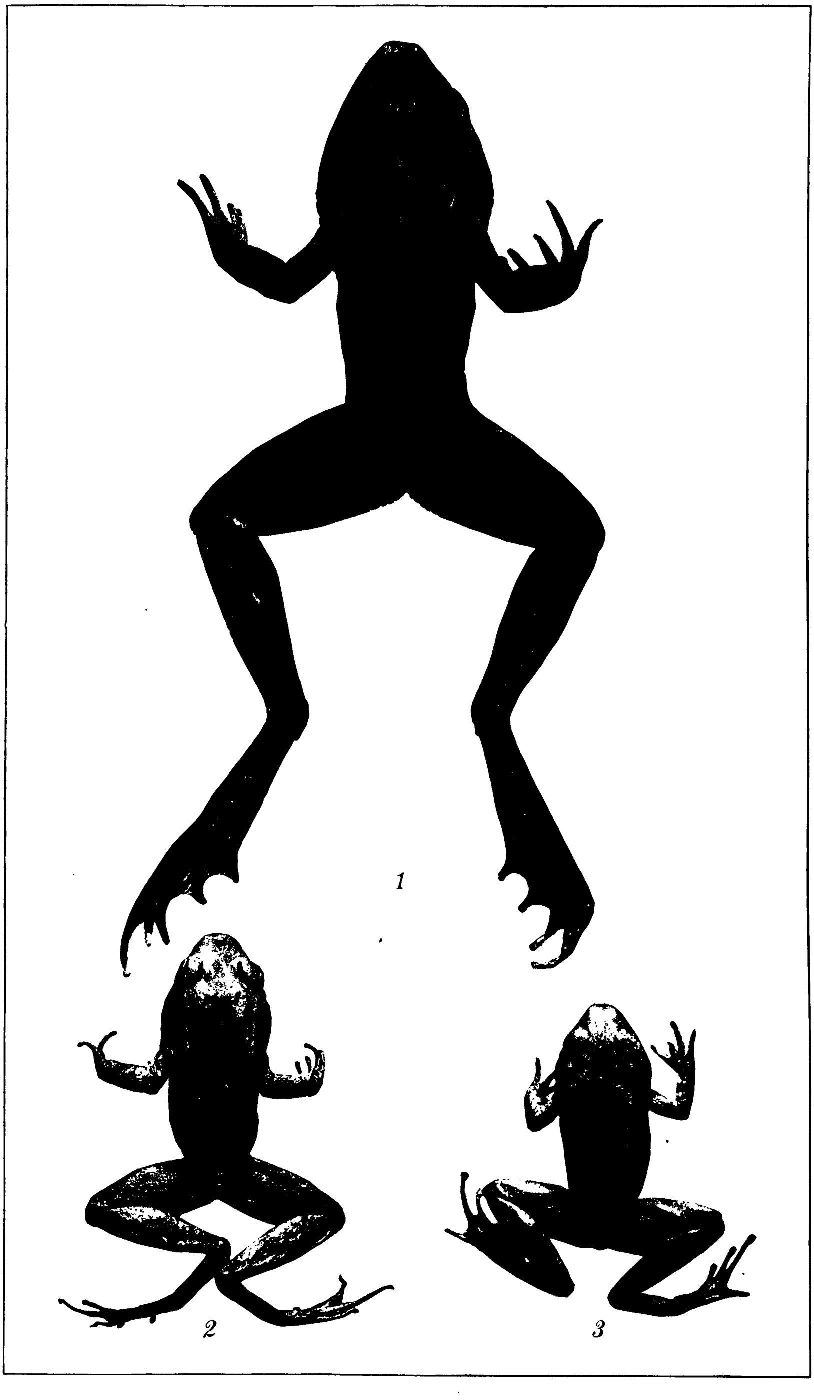

PLATE 2.

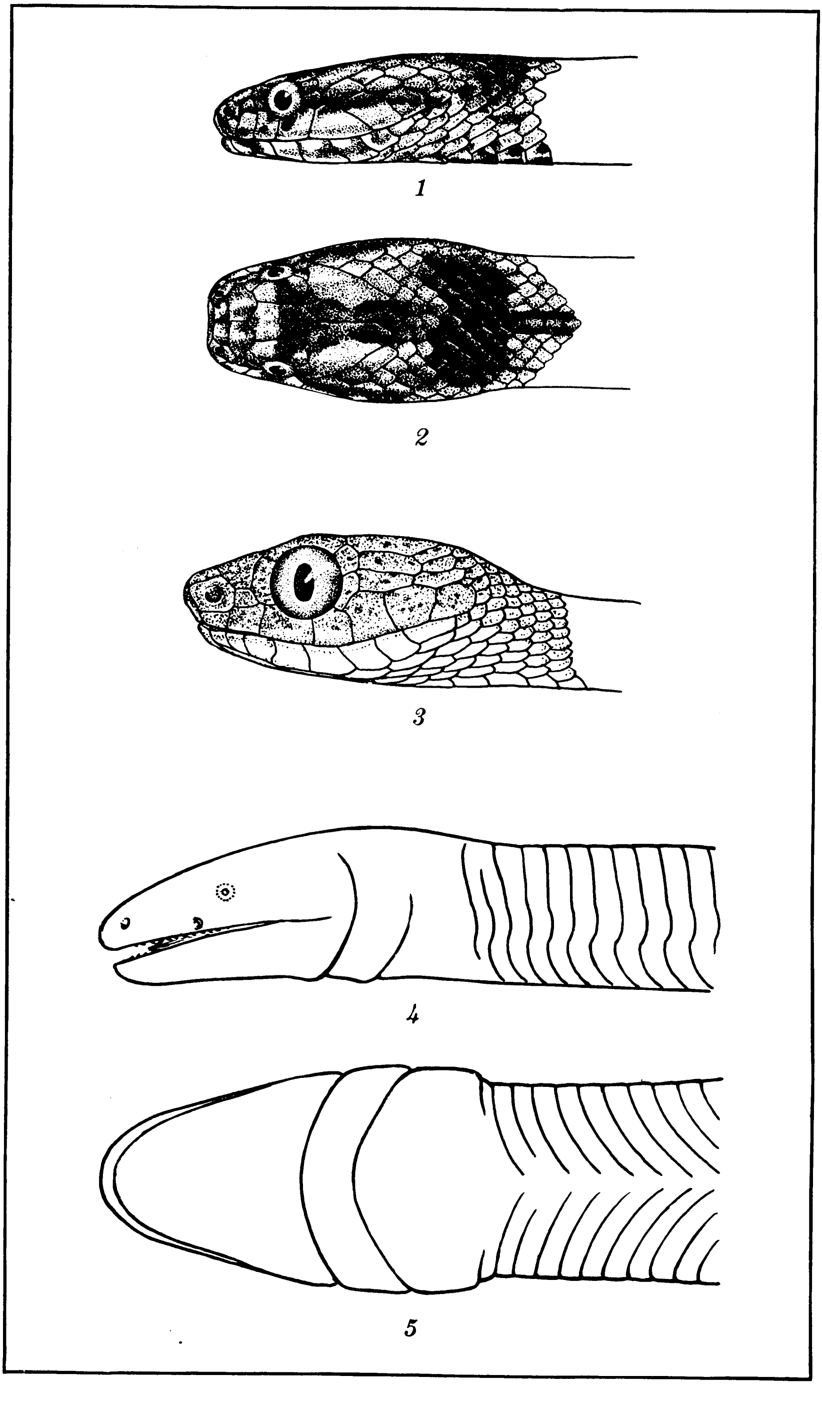

PLATE 3.

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THE PHILIPPINE JOURNAL OF SCIENCE

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DIPHTHERIA CARRIERS AND THEIR SIGNIFICANCE IN THE PHILIPPINES

By LIBORIO GOMEZ and REGINO NAVARRO

Of the Bureau of Science, Manila

Previous papers have demonstrated the low incidence of diphtheria among Filipinos, although it was also shown that Filipino children are just as susceptible to diphtheria infection as are the children of other races.[1]

The next step in the study of the local diphtheria situation would be the study of the incidence of diphtheria carriers and the significance of the bacilli harbored by them, which might have a bearing on the low incidence of the disease, and such data might prove valuable from the standpoint of public sanitation. With this object in view we have made careful cultural studies of material obtained from the throats of about 1,775 healthy individuals to determine the prevalence of diphtheria carriers in the Philippines, and animal tests have been performed to determine the virulence of the different strains of diphtheria bacilli isolated in pure culture.

MATERIAL AND TECHNIC

The search for carriers was started on account of a case of clinical diphtheria that occurred in a pupil attending the Santa Clara Public School, Manila. We examined 990 children of various ages attending the Santa Clara Public School, many of

[1] Gomez, Liborio; Kapauan, Amando M.; and Gavino, Catalino, Diphtheria in the Philippine Islands, Philip. Journ. Sci. 17 (1920) 37. Gomez, Liborio; Navarro, Regino; and Kapauan, Amando M., The Schick reaction in Filipinos, Philip. Journ. Sci. 20 (1922) 323.

whom had been in more or less intimate contact with the case of clinical diphtheria reported; 232 children from 1 to 15 years old, inmates of the Philippine Government Orphanage at San Pedro Macati, near Manila, where no diphtheria has ever occurred since the establishment of the institution in 1917; and 553 male and female adults of Bilibid Prison where diphtheria has never been known to occur.

One specimen was taken from each child and in cases where the results were doubtful another specimen was obtained. With the aid of a wooden tongue depressor, the tonsils and pharynx were swabbed with a sterile cotton pledget attached at the end of a small applicator stick. The swab was rubbed against the tonsils and pharynx by revolving the stick in the fingers in such a way as to bring the swab thoroughly in contact with the tonsils and the lacunæ or with any area at the pharynx that looked suspicious. The infected swab was then inserted into a Loeffler's serum tube and rubbed gently back and forth over the entire surface of the serum, revolving the stick so as to bring the swab in thorough contact with the serum, avoiding at the same time any break in the surface of the slant; and afterwards the swab was thrown away.

The inoculated Loeffler's blood serum tubes were taken to the laboratory and after incubation of from eighteen to twenty-four hours at 37° C. the cultures were examined, and all suspicious colonies (whitish, pearly, rather elevated) and the bottom of the tube (when there was proteolysis of the serum) were examined microscopically. The smears were stained with Loeffler's methylene blue, and the colonies showing suspicious bacilli were either fished out with a fine platinum needle and transplanted to several Loeffler's blood serum tubes in order to get discrete colonies, or plated in glycerine agar in order to be able to get pure cultures. In some cases one single colony was transplanted; in other cases several colonies were transplanted, especially when isolation was made by the glycerine agar plate method where the colonies are so small and hard to pick out with the point of the needle. In such cases a small area was marked out and examined microscopically to determine uniformity of colonies; the area was then rubbed over with a fine platinum loop and smeared on Loeffler's blood serum.

The morphology of the bacteria was studied in cultures from eighteen to twenty-four hours old, in Loeffler's blood serum, and stained with Loeffler's methylene blue, Neisser-Gin, and Gram's

stain. In all cases we inoculated Hiss's serum carbohydrate media tubes of glucose, saccharose, and dextrin. For control purposes media of the same batch were simultaneously inoculated with known cultures of diphtheria bacilli, Park Williams 8, Xerosis bacillus isolated from the throat and from the eye, and Hoffmann's bacillus.

The isolated bacteria were considered diphtheria bacilli if they showed positive Gram's stain, typical arrangement, typical polar bodies, or metachromatic granules and, in Hiss's serum media, if the glucose was acidified strongly, the dextrin slightly, and the saccharose not at all, thus differing from the Xerosis bacillus which does not acidify dextrin but does acidify saccharose, while Hoffmann's bacillus does not acidify any of the three sugars used.

The virulence test was performed on all the strains isolated from the carriers. The test was performed by subcutaneous injection in the middle line of the abdominal wall of a guinea pig, weighing 250 to 300 grams, of 4 cubic centimeters of a 10-cubic-centimeter salt solution emulsion of a twenty-four hours old Loeffler's blood serum culture, according to the method of Kolmer and Moshage.[2] The criterion used in considering virulence of the bacilli was the following set of findings: Local subcutaneous œdema of the abdominal walls, hyperæmia of the adrenals, and death of the guinea pig within four days after inoculation.

INCIDENCE OF CARRIERS

All the organisms isolated were Gram positive bacilli of the granular type corresponding to the types B, C, and D of Wesbrook and, in one case, type E, which looks almost like a diplococcus when stained with Loeffler's methylene blue, but shows distinct granular bodies when stained with Neisser-Gin stain.

From 1,222 children of various ages, pupils attending Santa Clara Public School and inmates of the Philippine Government Orphanage at San Pedro Macati, there were isolated 32 pure cultures of diphtheria bacilli. From 553 adult males and females in Bilibid Prison, there were isolated 6 pure cultures. In all of these, the diphtheria bacilli were identified culturally, morphologically, and by the acid reaction in Hiss's carbohydrate media.

The total number of individuals examined, therefore, was 1,775, from 38, or 2.08 per cent, of whom pure cultures of

[2] Journ. Inf. Dis. 19 (1916) 1.

diphtheria bacilli were isolated. The actual number of carriers in a group of healthy individuals is higher, because we often noticed in smears from the original cultures typical bacilli, which we were unable to isolate on account of too great contamination or of some defect in the technic, and because only one specimen was taken and examined from each individual in practically all cases. The above figures, however, give us a general idea of the existence of diphtheria bacilli in the throats of a group of healthy individuals in the Philippines.

Two years after the first examination in the Philippine Government Orphanage at San Pedro Macati another survey was made of the inmates. There were 217 examined, including most of the children previously examined. Nine were found to harbor diphtheria bacilli, in the throat of one of whom the diphtheria bacilli had also been found two years previously.

Physical examination of the throat of the carriers failed to show anything characteristic, although many of them had moderately enlarged tonsils.

VIRULENCE TEST

Thirty-five of the thirty-eight cultures isolated were tested for virulence according to the method mentioned previously. The other three cultures were either spoiled or lost and no virulence test was performed with them. The results of these tests are shown in Table 1.

Four cultures (5, 23, 25, and 33) out of the thirty-five were considered virulent because the injected guinea pigs died within four days after inoculation, with subcutaneous œdema, usually hæmorrhagic, and intense congestion of the adrenals. One of the individuals harboring virulent diphtheria bacilli, M.M., a girl about 9 years old, developed clinical diphtheria two days after examination; and the other three (A.S. and N.C., school boys, and B75, adult male) have never shown clinical symptoms. Two other cultures (obtained from P.M. and I.L., school children) were considered slightly virulent, as the animals injected with them died after six days and showed slight local subcutaneous œdema and slight or distinct hyperæmia of the adrenals.

The other twenty-nine cultures were considered nonvirulent. Guinea pigs that die after injection of the virulent culture live longer than four days and death often occurs after a considerable period of time, either from intercurrent infection or from intoxication due to absorption of bacterial body proteids; death

TABLE 1.—*Virulence test of Bacillus diphtheriæ isolated from carriers at different times.*

Culture No.	Carrier.	Effect of injection on guinea pigs.			
		Subcutaneous œdema.	Congestion of adrenals.	Died after injection.	Alive after injection.
				Days.	*Days.*
1	P. M	+[a]	+	6	
2	C. P	—	([a])	8	
3	F. A	—	+[a]	42	
4	T. S	—	+	10	
5	M. M.[b]	+	+	[c]2	
6	C. C	—	—	48	
7	V. S	—	+[a]	18	
8	A. C	—			65
9	A. O	—	—	26	
10	J. P	—			65
11	I. L	—	—	10	
12	A. V	—	+[a]	8	
13	S. A	—	—	17	
14	J. E	—			19
15	I. S	—	+[a]	18	
16	D. R	—	+[a]	10	
17	F. A	—	—	22	
18	C. P	—	—	36	
19	P. S	—	—	43	
20	M. V	—			53
21	I. L	+[a]	+[a]	6	
22	J. L	—	+[a]	18	
23	A. S	+	+	[c]2	
24	F. M	—			52
25	N. C	+	+	[c]1	
26	J. L	—	+ ?	33	
27	G. C	—	—	5	
28	N. I	—			6
29	G. W	—			6
30	M. S	—			13
31	B3	+[a]	+[a]	22	
32	B38	—	—	21	
33	B75	+	+	[c]3	
34	B110	+[a]	+	12	
35	B156	—	—	13	

[a] Slight.
[b] This carrier developed clinical diphtheria two weeks subsequent to examination.
[c] Virulent cultures.

under those conditions is not distinguishable from the death of animals after injection of massive doses of other bacteria.

In no case were we able to notice paralytic symptoms in guinea pigs used in these tests indicative of diphtheria intoxication.

DISCUSSION OF FINDINGS

Graham-Smith,[3] tabulating the findings of several authors, found that 2.6 per cent of persons who have not come in contact with diphtheria cases harbor nonvirulent diphtheria bacilli, and 0.18 per cent harbor virulent bacilli.

The number of cases that we have examined is fairly representative of the entire population of Manila, although our findings, 2.08 per cent of healthy individuals being carriers, are necessarily low on account of our having examined only one specimen from practically all the cases. These findings are sufficient to establish the fact that there is a certain percentage of people in the population in Manila that harbor diphtheria bacilli; and that the diphtheria bacilli found in normal throats are usually nonvirulent, a small proportion being virulent; that is, four, or 11 per cent, of the thirty-five isolated, or about 0.22 per cent of the total number of people examined. This is in striking contrast with the findings in cultures of diphtheria bacilli isolated from clinical cases in San Lazaro Hospital, practically all of which have been found to be virulent. The nonvirulent bacilli isolated differ in no other respect, morphologically and culturally, from those isolated from the throats of patients suffering from the disease.

The work in the Santa Clara Public School was started on account of a case of diphtheria that occurred in one of the pupils. Another pupil (M.M.), in an entirely different room from the one that was first taken sick, was found to be a carrier of virulent bacilli and later developed a mild clinical diphtheria. All the carriers from the school were isolated at the San Lazaro Hospital, at different periods, and given treatment until the diphtheria bacilli disappeared. The work connected with the taking of specimens and the detection and isolation of individual carriers was done within a period of about forty days. No other cases of diphtheria developed in the school or among people with whom the two cases of diphtheria associated in their homes, although a sufficient period of time had elapsed, before the detection and isolation of the carriers, for the possible spread of the disease.

In the Government Orphanage at San Pedro Macati no case of clinical diphtheria has developed since its establishment in 1917, although carriers were found in the institution at the first

[3] Nuttall, G. H. F., and Graham-Smith, G. S., The Bacteriology of Diphtheria. Cambridge (1908) 194.

examination, in 1919 (in one instance the bacilli were virulent), and there were children susceptible to diphtheria as shown by results of the performance of the Schick's test. In this institution we have data of the constant existence of carriers, in spite of the isolation of those detected previously. Two years later another examination was made of the inmates of the orphanage. From 217 inmates (most of whom had been examined two years previously) 9 pure cultures were isolated, all of which proved to be nonvirulent in the animal tests; also, one of the positive carriers (G.C.) was found to have harbored the bacilli two years previously.

We see from the above that, in spite of association with clinical cases and with persons harboring diphtheria bacilli, the disease has not spread in a school (Santa Clara) with a daily attendance of about one thousand. In an institution (Philippine Government Orphanage) where there is more or less intimate association among the children, and where there were always carriers and persons susceptible to the disease, clinical diphtheria has never been known to develop in the five years of its existence. In another institution, Bilibid Prison, no diphtheria has been known to occur for some years before these carrier examinations were made, in spite of the existence of carriers of avirulent and of virulent diphtheria. It is the present consensus that diphtheria bacilli which are found by laboratory test to be nonvirulent are not harmful to human beings, and healthy persons harboring nonvirulent bacilli need not be isolated. This criterion has been recently confirmed experimentally by inoculation of the throats of human beings with virulent and with nonvirulent diphtheria bacilli by Guthrie, Marshall, and Moss.[4]

SUMMARY

1. At least a certain percentage (2.08) of healthy individuals in the Philippine Islands harbor diphtheria bacilli in their throats.

2. The diphtheria bacilli harbored in healthy persons have been found nonvirulent in about 89 per cent, and virulent in about 11 per cent of the carriers.

[4] Moss, W. L.; Guthrie, C. G.; and Marshall, B. C., Experimental inoculation of human throats with avirulent diphtheria bacilli, Johns Hopkins Hosp. Bull. 32 (1921) 37. Guthrie, C. G.; Marshall, B. C.; and Moss, W. L., Experimental inoculation of human throats with virulent diphtheria bacilli, Johns Hopkins Hosp. Bull. 32 (1921) 369.

3. In a school where two cases of clinical diphtheria developed and where carriers of both nonvirulent and virulent bacilli were found, the disease has not spread to the other children of the school or to the other people with whom the carriers and cases came in daily intimate association, which confirms the notion that the disease does not become epidemic in Manila.

4. In spite of the continuous existence of carriers of nonvirulent bacilli and the occasional existence of virulent ones in persons living in institutions where a certain number have been proved to be susceptible to the disease by Schick's test, no clinical diphtheria has ever been known to develop among the inmates.

5. From the above data one must conclude that, for the control of diphtheria in the Philippines, it is only necessary to examine the throats of the individuals who have come in intimate contact with cases, to isolate those who are carriers, and to liberate them later if the animal tests show that the bacilli they harbor are not virulent.

ACKNOWLEDGMENT

We desire to express our appreciation of the courtesies extended us by Dr. Antonio Mañalac, of Bilibid Prison, and by Dr. Severo Siasoco, of the Philippine Government Orphanage.

HYPERSENSITIVENESS OF PHILIPPINE DOGS TO STRYCHNINE

By MIGUEL MANRESA

College of Veterinary Science, University of the Philippines

INTRODUCTION

The belief has long been entertained by some veterinarians of the Philippine Islands that native dogs possess a hypersensitiveness to the action of strychnine sulphate and other salts of that alkaloid. This belief is founded entirely upon personal experience in administering the drug to these animals with untoward results, so that the grounds are essentially empirical and without scientific basis. Reports, however, have been so numerous of cases wherein strictly therapeutic doses of strychnine sulphate have produced the characteristic symptoms of acute strychnine poisoning as to give great weight to the view, and the opinion may be said to have become confirmed in the minds of many.

As an illustration of these unfavorable clinical sequelæ which have apparently occurred so often, an experience may be cited which I had while employed as an assistant in a veterinary hospital in Manila. To each of two pups, weighing between 5 and 6 kilograms each, was given a tablet of triple arsenites, containing $\frac{1}{120}$ of a grain of strychnine arsenite to the tablet, an amount not in excess of that indicated in most textbooks. The intention was to administer one of these tablets daily, but about twenty minutes after the administration of the second dose acute convulsive attacks in both animals occurred. These attacks increased in intensity as they recurred until death ensued, about thirty minutes after the administration of the drug.

The dose of strychnine by the different channels of administration for dogs in temperate climates has been carefully determined by various workers, but to my knowledge no similar work has been undertaken under tropical conditions, and certainly not locally. Therefore, in view of the foregoing considerations the question naturally arises: Does the apparent hypersusceptibility of native dogs to strychnine actually exist, or can the

unusual effects so often manifested be accounted for in some other manner? The experiments that form the subject of this paper were undertaken with the object of inquiring into this phase of the matter and of endeavoring, if possible, to throw some light of a definite nature upon this interesting but rather moot question.

REVIEW OF LITERATURE

The therapeutic dose of strychnine sulphate as given by veterinary textbooks falls between 0.0003 and 0.003 of a gram ($\frac{1}{200}$ to $\frac{1}{20}$ of a grain). Udall(13) gives 0.001 to 0.003 gram ($\frac{1}{60}$ to $\frac{1}{20}$ grain) as the dose for internal administration and one-half of this amount for subcutaneous use. Brumley(1) gives 0.00104 to 0.00302 gram ($\frac{1}{62}$ to $\frac{1}{21}$ grain) [1] and Frohner,(3) 0.001 to 0.003 gram ($\frac{1}{70}$ to $\frac{1}{25}$ grain). Dun(2) fixes the maximum at 0.00065 to 0.0013 gram [1] ($\frac{1}{100}$ to $\frac{1}{50}$ grain) and writes that tablets and lamellæ containing 0.001 to 0.0006 gram [1] ($\frac{1}{60}$ to $\frac{1}{100}$ grain) of strychnine sulphate are convenient for subcutaneous injections. Winslow(14) gives 0.0003 to 0.0015 gram ($\frac{1}{200}$ to $\frac{1}{40}$ grain) advising that the larger doses are to be given when administered orally. He states further that these doses may be given every three hours without producing poisoning by accumulation. On account of the extreme susceptibility occasionally observed, particularly in dogs, Winslow,(14) Udall,(13) and Frohner(3) advise that all doses should be apportioned to the body weight, and fix the dose at 0.0001 gram ($\frac{1}{600}$ grain) per kilogram of body weight for subcutaneous injections.

Concerning the elimination of strychnine there is more discrepancy among the various reports. On the one hand, Lander(9) is authority for the statement that the elimination of strychnine is not complete even in three days; Plugge(11) states that although strychnine appears in the urine two hours after its injection traces may be found as late as the eighth day; this statement is supported by Winslow,(14) who says that strychnine may be found in the urine from three to eight days after its administration. On the other hand, according to Kratter,(8) the excretion of strychnine is complete at the expiration of forty-eight hours. In two experiments performed by Hale,(4) on a normal healthy human adult weighing 160 pounds (about 73 kilograms), with strychnine sulphate given by the stomach he found complete elimination after five days. Mostrom and

[1] Computation is mine.—M. M.

McGuigan,(10) testing for the presence of strychnine nitrate, at weekly intervals in no less than forty-eight frogs obtained a negative result in every instance.

The fatal dose of strychnine is given by Dun(2) and by Lander(9) as 0.0054 to 0.0216 gram[2] (1/12 to 1/3 grain). Winslow(14) found this dose to be "much too large." He injected 3.24 milligrams (1/20 grain) of strychnine nitrate subcutaneously into a dog weighing 25 pounds (0.29 milligram per kilogram)[2] and observed tetanic convulsions within ten minutes. He also reports cases where toy terriers were killed by 1.08 milligrams (1/60 grain) of the alkaloid. Kaufmann(6) and Kobert(7) give 0.75 milligram per kilogram as the fatal dose, but Hale(4) found this dose "entirely too large." Hoare(5) observed several cases of intoxication after administering so-called therapeutic doses of strychnine and writes that the doses advised in his work are "too large and that greater care is necessary in prescribing them in full doses." More specific figures are given by Sollmann,(12) who determined the minimal lethal dose per kilogram of body weight by the different channels of administration to be as follows: By the stomach, 1.2 to 3.9 milligrams; subcutaneously, 0.35 to 0.75 milligram; intravenously, 0.4 milligram; by the rectum, 2 milligrams; and through the bladder, 5.5 milligrams.

PROCEDURE

The experiments described in the following pages were conducted in the College of Veterinary Science, University of the Philippines, Los Baños, from March 6 to July 31, 1922. Twelve dogs were utilized in the work, of which ten were obtained from the Manila City Pound and two in the vicinity of Los Baños. The salt of strychnine used was the sulphate (Park Davis and Company, Detroit, Mich., U. S. A.) in the form of friable tablets containing 0.5 grain each. Enough of these tablets were placed in a volumetric flask with sufficient water to make 1,000 cubic centimeters of a 1 to 1,000 per cent solution. The frequency of the administration of the solution throughout the experiment was at intervals of seven days. The live body weight of each dog was ascertained by weighing previous to each administration of the drug, and the dosage was apportioned in accordance with this determination. Following the administration the animals were placed under conditions which simulated as closely as possible those to which they had been accustomed. During the

[2] Computation is mine.—M. M.

early part of the experiment and before the appearance of convulsive symptoms the recording of the pulse, respiration, and temperature constituted a part of the regular procedure. Close observation was made for any increase in reflexes that might be manifested, and the results of such observations were carefully noted. The effects of strychnine produced in the varying doses employed by the various channels of administration are shown by the data which follow. The experiments were so conducted that two dogs received the drug by mouth; four, subcutaneously; two, intravenously; three, by rectum; and one, intramuscularly.

RESULTS

The results of these experiments are given in five tables. Table 1 gives the results of administration by mouth. The mouth was carefully lubricated with molasses and the calculated amount of strychnine sulphate was given by means of a

TABLE 1.—*Dogs receiving strychnine sulphate by mouth.*

DOG 1, ADULT FEMALE.

Date.	Weight.	Dose in milligrams per kilogram.	Remarks.
	Grams.		
April 24	8,200	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 1	8,300	0.075	Do.
May 8	8,400	0.1	Reflexes slightly increased after 29 minutes.
May 15	8,400	0.175	Reflexes increased after 27 minutes.
May 22	8,200	0.25	Reflexes increased after 23 minutes.
May 29	8,200	0.35	Just convulsive after 20 minutes.
DOG 2, ADULT MALE.			
April 24	6,000	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 1	6,200	0.075	Do.
May 8	6,400	0.1	Reflexes increased after 23 minutes.
May 15	6,300	0.175	Reflexes markedly increased after 34 minutes.
May 22	6,600	0.25	Reflexes markedly increased after 20 minutes.
May 29	6,600	0.35	Just convulsive after 21 minutes.
June 5	6,400	0.47	Just tetanic after 15 minutes.
June 12	6,800	0.8	Tetanic convulsions.
June 19	7,000	1	Just fatal after 33 minutes.

TABLE 2.—*Dogs receiving subcutaneous injections of strychnine sulphate.*

DOG 3, ADULT FEMALE.

Date.	Weight.	Dose in milligrams per kilogram.	Remarks.
	Grams.		
April 25	7,400	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 2	7,400	0.075	Do.
May 9	7,000	0.1	Reflexes markedly increased after 15 minutes.
May 16	7,000	0.13	Reflexes markedly increased after 13 minutes.
May 23	7,400	0.175	Just convulsive after 9 minutes.
May 30	7,600	0.25	Just tetanic after 12 minutes.
June 6	7,600	0.35	Tetanic convulsions.
June 13	7,600	0.47	Just fatal after 21 minutes.
DOG 4, ADULT FEMALE.			
April 25	6,800	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 2	7,300	0.075	Do.
May 9	6,600	0.1	Reflexes not markedly changed.
May 16	6,800	0.13	Reflexes markedly increased after 15 minutes.
May 23	7,200	0.175	Just moderately convulsive after 19 minutes.
May 30	7,400	0.25	Just tetanic after 18 minutes.
June 6	7,400	0.35	Tetanic convulsions.
June 13	7,600	0.47	Do.
June 20	7,600	0.60	Do.
June 27	7,800	0.75	Just fatal after 16 minutes.
DOG 5, ADULT MALE.			
June 24	7,400	0.25	Just convulsive after 42 minutes.
July 1	6,800	0.35	Convulsion after 22 minutes.
July 8	7,000	0.47	Just tetanic after 20 minutes.
July 15	7,000	0.60	Tetanic convulsions.
July 22	7,400	0.75	Just fatal after 40 minutes.
DOG 6, ADULT MALE.			
March 6	8,000	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
March 13	8,000	0.075	Do.
March 20	8,200	0.1	Marked increase of reflexes.
March 27	8,000	0.175	Do.
April 3	8,000	0.20	Just convulsive.
April 10	8,100	0.25	Just tetanic.
April 17	8,200	0.35	Just fatal.

TABLE 3.—*Dogs receiving intravenous injections of strychnine sulphate.*

DOG 7, ADULT FEMALE.

Date.	Weight.	Dose in milligrams per kilogram.	Remarks.
	Grams.		
April 26	8,800	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 3	8,800	0.075	Immediate acceleration of reflexes.
May 10	8,600	0.1	Do.
May 17	8,000	0.13	Convulsion after 30 seconds.
May 24	8,000	0.175	Tetanic convulsions.
May 31	8,600	0.25	Do.
June 7	8,400	0.35	Do.
June 14	8,500	0.4	Fatal after 3 minutes.
DOG 8, ADULT MALE.			
April 26	7,400	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 3	6,700	0.075	Immediate acceleration of reflexes.
May 10	6,800	0.1	Do.
May 17	6,800	0.13	Just convulsive.
May 24	6,600	0.175	Tetanic convulsions.
May 31	6,800	0.25	Do.
June 7	6,800	0.35	Fatal after 12 minutes.

hypodermic syringe provided with a long needle the end of which had been rounded off. No difficulty was experienced in giving the drug.

Table 2 gives the results of subcutaneous injections. The site selected was the costal region on either side of the chest.

Table 3 gives the results of intravenous administrations. The dogs were carefully secured and the injections were made into either the posterior auricular or the external metatarsal vein. The solution was injected at body temperature.

Table 4 gives the results of rectal administration. The animals were allowed to defecate before the drug was given and if fæces were not passed the rectum was manually cleaned out before each administration. The calculated amount of the solution to be used was each time heated to body temperature and administered by means of a syringe provided with a long, blunt-

pointed needle around which a wide elastic band had been rolled, and on top of which a thick layer of vaseline was applied. The animals were kept absolutely quiet for a period of ten minutes to avoid tenesmus and rejection of the solution administered, thereby insuring its absorption.

Table 5 gives the results of intramuscular administration. The site of injection selected was the fleshy portion of either thigh.

TABLE 4.—*Dogs receiving strychine sulphate per rectum.*

DOG 9, ADULT FEMALE.

Date.	Weight.	Dose in milligrams per kilogram.	Remarks.
	Grams.		
April 27	8,000	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 4	8,000	0.075	Do.
May 11	8,600	0.1	Do.
May 18	8,400	0.13	Reflexes increased.
May 25	8,000	0.175	Reflexes greatly increased.
June 1	8,400	0.25	Do.
June 8	8,800	0.35	Do.
June 15	8,800	0.60	Tetanic convulsions.
June 22	8,800	1	Do.
June 29	8,800	1.5	Fatal after 20 minutes.
DOG 10, ADULT MALE.			
April 27	5,700	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 4	6,000	0.075	Do.
May 11	6,800	0.1	Do.
May 18	6,600	0.13	Reflexes increased.
May 25	6,000	0.175	Reflexes greatly increased.
June 1	6,200	0.25	Do.
June 8	6,600	0.35	Tetanic convulsions.
June 15	6,600	0.60	Do.
DOG 11, ADULT FEMALE.			
June 22	8,800	1	Reflexes greatly increased after 25 minutes.
June 29	8,800	1.5	Tetanic convulsions.
July 6	8,700	2	Fatal after 26 minutes.

TABLE 5.—*Dogs receiving intramuscular injections of strychnine sulphate.*

DOG 12, ADULT FEMALE.

Date.	Weight.	Dose in milligrams per kilogram.	Remarks.
	Grams.		
April 28	5,500	0.05	No appreciable effect in either pulse, respiration, or temperature. Reflexes not increased.
May 5	6,000	0.075	Do.
May 12	6,400	0.08	Do.
May 19	6,200	0.13	Reflexes increased after 15 minutes.
May 26	6,200	0.175	Convulsion after 12 minutes.
June 2	6,200	0.25	Tetanic convulsions.
June 9	6,400	0.35	Do.
June 16	6,800	0.4	Fatal after 1 hour, 24 minutes.

SUMMARY OF RESULTS [3]

From the preceding tables it is seen that:

1. In administration by mouth:
   - *a.* No appreciable effects were produced with doses as high as 0.75 milligram.
   - *b.* Hyperexcitability was produced by 0.1 to 0.25 milligram.
   - *c.* Convulsion was produced by 0.35 milligram.
   - *d.* Tetanic convulsions were produced by 0.47 to 0.8 milligram.
   - *e.* Fatal result was produced by 1 milligram.
2. In subcutaneous administration:
   - *a.* No appreciable effects were produced with doses as high as 0.075 to 0.1 milligram.
   - *b.* Hyperexcitability was produced by 0.1 to 0.175 milligram.
   - *c.* Convulsion was produced by 0.175 to 0.2 milligram.
   - *d.* Tetanic convulsions were produced by 0.25 to 0.6 milligram.
   - *e.* Fatal result was produced by 0.35 to 0.75 milligram.
3. In intravenous administration:
   - *a.* No appreciable effects were produced with doses as high as 0.05 milligram.
   - *b.* Hyperexcitability was produced by 0.075 to 0.1 milligram.
   - *c.* Convulsion was produced by 0.13 milligram.
   - *d.* Tetanic convulsions were produced by 0.175 to 0.35 milligram.
   - *e.* Fatal result was produced by 0.35 to 0.4 milligram.
4. In rectal administration:
   - *a.* No appreciable effects were produced with doses as high as 0.1 milligram.
   - *b.* Hyperexcitability was produced by 0.13 to 0.35 milligram.
   - *c.* Tetanic convulsions were produced by 0.35 to 1.5 milligrams.
   - *d.* Fatal result was produced by 1.5 to 2 milligrams.

[3] All figures are milligrams per kilograms of body weight.

5. In intramuscular administration:
   a. No appreciable effects were produced with doses as high as 0.08 milligram.
   b. Hyperexcitability was produced by 0.13 milligram.
   c. Convulsion was produced by 0.175 milligram.
   d. Tetanic convulsions were produced by 0.25 to 0.35 milligram.
   e. Fatal result was produced by 0.4 milligram.

Table 6 gives the summary of results in another form.

TABLE 6.—*Summary of results of administering strychnine to dogs.*

[NE, no appreciable effect; Hx, hyperexcitability; CE, convulsive effect; TC, tetanic convulsions; FR, fatal result.]

Dog No.	Administration.	Milligrams per kilogram of body weight.										
		0.05	0.075	0.08	0.1	0.13	0.175	0.2	0.24	0.25	0.315	0.35
1	Oral	NE	NE	------	Hx	Hx	Hx	Hx	Hx	Hx	------	CE
2	Do	NE	NE	------	Hx	Hx	Hx	Hx	Hx	Hx	------	CE
3	Subcutaneous	NE	NE	------	Hx	Hx	CE	------	------	TC	TC	TC
4	Do	NE	NE	NE	NE	Hx	CE	------	------	TC	TC	TC
5	Do	------	------	------	------	------	------	------	------	CE	------	TC
6	Do	NE	NE	------	Hx	Hx	Hx	CE	------	TC	------	FR
7	Intravenous	NE	Hx	Hx	Hx	CE	TC	TC	TC	TC	TC	TC
8	Do	NE	Hx	Hx	Hx	CE	TC	TC	TC	TC	------	FR
9	Rectal	NE	NE	NE	NE	Hx	Hx	Hx	Hx	Hx	Hx	Hx
10	Do	NE	NE	NE	NE	Hx	Hx	Hx	Hx	------	------	TC
11	Do	------	------	------	------	------	------	------	------	------	------	------
12	Intramuscular	NE	NE	NE	------	Hx	CE	------	------	TC	TC	TC

Dog No.	Administration.	Milligrams per kilogram of body weight.										
		0.39	0.4	0.47	0.5	0.55	0.6	0.75	0.8	1.0	1.5	2.0
1	Oral	------	------	------	------	------	------	------	------	------	------	------
2	Do	------	------	TC	TC	TC	TC	TC	TC	FR	------	------
3	Subcutaneous	------	------	FR	------	------	------	------	------	------	------	------
4	Do	TC	TC	TC	TC	TC	TC	FR	------	------	------	------
5	Do	TC	TC	TC	TC	TC	TC	FR	------	------	------	------
6	Do	------	------	------	------	------	------	------	------	------	------	------
7	Intravenous	------	FR	------	------	------	------	------	------	------	------	------
8	Do	------	------	------	------	------	------	------	------	------	------	------
9	Rectal	------	------	------	------	------	TC	TC	TC	TC	FR	------
10	Do	TC	TC	TC	TC	TC	TC	------	------	------	------	------
11	Do	------	------	------	------	------	------	------	------	------	TC	FR
12	Intramuscular	------	FR	------	------	------	------	------	------	------	------	------

At the time of the conclusion of the experiment just described, the professor of parasitology had completed some investigations pertaining to the efficiency of anthelmintics. The eight dogs utilized in his work were about to be discarded, and at my request they were placed at my disposal.

These animals were employed in an experiment having for its object the determination of the relative resistance of native dogs to strychnine and, consequently, was in a sense supplemental to the first experiment. The minimum dose which had proved fatal in the first experiment was injected subcutaneously in all the dogs. To those that did not succumb to this amount, and after the acute symptoms had subsided, an additional amount of strychnine equal to the difference between the next fatal dose (determined as before) and the one injected was administered. This procedure of administering additional strychnine sufficient to equal the next succeeding lethal dose was repeated until all the animals finally died. The results obtained are given in Table 7.

TABLE 7.—*Dogs receiving fatal doses of strychine sulphate by subcutaneous administration.*

[Amounts injected are in milligrams per kilogram of body weight.]

Dog No.	Weight.	First.	Injection.	Second.	Injection.	Third.	Injection.	Died.
	g.	*Time.*	*mg.*	*Time.*	*mg.*	*Time.*	*mg.*	*Time.*
13	8,000	10.35	0.35	2.12	0.12			2.30
14	10,250	10.54	0.35					11.14
15	8,400	10.09	0.35	2.30	0.12			2.57
16	2,400	10.00	0.35					10.17
17	6,200	10.23	0.35	1.10	0.12			1.30
18	9,200	10.05	0.35	12.40	0.12	3.03	0.13	3.18
19	11,600	10.57	0.35	1.49	0.12			2.10
20	9,600	10.15	0.35	1.04	0.12			1.30

TABLE 8.—*Summary of data in Table 7.*

Injections.				Dogs died.	
First dose.	Second dose.	Third dose.	Total.		
mg.	*mg.*	*mg.*	*mg.*	*Number.*	*P. ct.*
0.35			0.35	2	25
0.35	0.12		0.47	5	62.5
0.35	0.12	0.13	0.60	1	12.5

DISCUSSION OF RESULTS

It will be noted from the experimental results obtained that the animals were uniformly slower in showing the early effect of the drug, namely, hyperexcitability, than were those experimented upon by Sollmann.(12) On the other hand, three of them were killed by rather smaller doses. For purposes of com-

parison tabulated results of the present experiments and those of Sollmann are here given:

TABLE 9.—*Effects of strychnine sulphate on non-anæsthetized animals.*

[All figures are milligrams per kilogram of body weight.]

RESULTS FROM THE PRESENT EXPERIMENT.

Effect.	Mouth.	Hypodermic.	Vein.	Rectum.	Intramuscular.
No appreciable effect	0.075	0.075	0.05	0.1	0.08
Hyperexcitability	0.1	0.1	0.075	0.13	0.13
Just convulsive	0.35	0.175-0.25	0.13	----------	0.175
Just tetanic	0.47	0.25	0.175	0.35	0.25
Just fatal	1.00	0.35-0.75	0.35-0.4	1.5-2	0.4

RESULTS OBTAINED FROM SOLLMANN.

Effect.	Stomach.	Hypodermic.	Vein.	Rectum.	Other channels.
No appreciable effect	----------	0.05	----------	0.05	----------
Hyperexcitability	0.075	0.075	0.075	0.075	[a] 0.08
Just convulsive	0.175	0.1-0.24	----------	0.1-0.24	----------
Just tetanic	0.47	0.25	----------	0.25	----------
Just fatal	1.2-3.9	0.35-0.75	0.4	2.00	[b] 5.5

[a] Intramuscular. [b] Bladder.

Excepting the results obtained by the oral and intramuscular modes of administration, which do not accurately check with those obtained by Sollmann,(12) the results of all other phases of the experiment are in substantial agreement with those obtained by him. In the case of the exceptions cited, the intramuscular injection of 0.08 milligram in Sollmann's work produced hyperexcitability, while in the present experiment the same dose administered by the same channel produced no appreciable effect. In administration by the mouth, 1.2 milligrams in Sollmann's experiment produced a fatal result, while in the present experiment a dose 0.2 milligram less than this amount had a similar termination. Very slight variations will be noted in the results obtained by the administration per rectum and per vein in the experiment of Sollmann and the one under consideration, as follows: In Sollmann's work 2 milligrams per rectum produced a fatal result, while in the present experiment 1.5 milligrams produced death in one animal, but another survived this amount and succumbed later to a dose of 2 milligrams, thereby agreeing with Sollmann's findings. A similar occurrence is revealed in the results obtained by intravenous injection. By

this method of administration 0.4 milligram proved fatal in Sollmann's experiment. In the present experiment a dose of 0.35 milligram produced the same result in one dog, while another survived this amount and succumbed to a later administration of 0.4 milligram. It will be seen, therefore, that these differences do not furnish a wide variation and that Sollmann's findings and mine coincide substantially in all essential particulars.

The minimal lethal dose (0.75 milligram) of Kaufmann(6) calculated per kilogram of body weight is found to be 2.14 times the minimal lethal dose for subcutaneous administration (0.35 milligram) obtained in the present experiment. This finding corroborates the statements emanating from Winslow(14) and Hale,(4) based upon experimental evidence, to the effect that the fatal dose as given by Kaufmann(6) is entirely too large. The smallest therapeutic dose per kilogram fixed by Winslow, Frohner,(3) and Udall(13) is [0.0001 milligram ($\frac{1}{600}$)] and is only 28.6 per cent of the minimal lethal dose as obtained in the present experiment. But the smallest therapeutic doses for gross use given by Dun,(2) Frohner, Udall, and Brumley(1) are greater than the minimal lethal dose obtained in this experiment by 0.30, 0.58, 0.65, and 0.69 milligram, respectively. When it is considered that the toy varieties of dogs, such as the different kinds of poodles, spaniels, Pekingese, and terriers, constitute a large percentage of the canine patients encountered in practice in the Philippines, an explanation of many cases of poisoning is presented that is easily understood.

Although the different investigators are at variance as to the exact length of time required for the complete elimination of strychnine, it is at least admitted that the drug is retained in the system for some time. Udall(13) advises that when the drug is given in doses that closely approach the maximum its administration be omitted every third day. Dun(2) warns against too frequent administration of the drug; and the results of the experiment summarized in Tables 7 and 8 prove that the practice of too frequent dosing with strychnine is prolific of dangerous consequences. It may be contended that the dogs referred to above, being experimental animals, were exhausted, depressed, debilitated, and weak; but, even admitting the correctness of the contention, it is precisely in these conditions that strychnine finds its therapeutic indication.

It is a matter of general knowledge that isolated cases of increased susceptibility or individual idiosyncrasy to strychnine are

fairly common, and numerous reports to substantiate this fact are on record. Winslow (14) states that "dogs appear sometimes extremely susceptible to strychnine." As remarked earlier, however, the clinical experience of many veterinarians with the administration of strychnine to dogs in the Philippines gives rise to the assumption that a hypersusceptibility or idiosyncrasy in these dogs is general and not exceptional. In order to state definitely whether such general hypersusceptibility exists or not either one or both of two proofs must be submitted: First, either an exceedingly large percentage of variation in a relatively small number of animals subjected to an experiment; or, second, a much larger number of individual cases of hypersensitiveness necessitating of course a much more extensive research into a larger number of animals.

In the present experiment the results obtained conform to those elicited by similar experiments performed in temperate countries to the extent of 75 per cent. In the variation of 25 per cent the range of difference noted was in most cases very slight. It is obvious, however, that these results cannot justify too hasty a generalization, and it is realized that the experiment was not conducted upon a scale sufficiently extensive to warrant the results being regarded as exhaustive or definitely conclusive. It is recommended, therefore, that the experiment be repeated and a more extensive research into a larger number of dogs be undertaken with the purpose of arriving at a definite solution of this rather important problem.

CONCLUSIONS

In conclusion, therefore, it must be said:

1. That a general hypersusceptibility of native dogs to strychnine has not been shown to exist by the present experiment, and
2. That the apparent hypersusceptibility reported must be explained as being due to one factor or to a combination of the following factors: (*a*) Relatively larger doses of strychnine than those given in veterinary textbooks when used in the Philippines. (*b*) Too frequent administration of the drug. (*c*) The peculiar hypersensitiveness or individual idiosyncrasy of isolated cases.

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V. NACHTRAG ZUR KENNTNIS DER PHILIPPINISCHEN RUTELIDEN (COLEOPTERA, LAMELLICORNIA)

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EINE TAFEL

Im Jahr 1910[1] gab ich eine Liste der bis dahin bekannten Rutelinen, die ich später[2] verbesserte und ergänzte. In den Jahren 1914, 1915, und 1916 gab ich weitere Nachträge;[3] seitdem sind mir wieder eine Anzahl neuer Arten zugegangen, die zum Teil von Herrn G. Boettcher, besonders aber von Herrn Prof. C. F. Baker gesammelt wurden. Eine zusammenfassende Bearbeitung der philippinischen Rutelinen verschiebe ich auf später, bis die grosse Ausbeute des Herrn G. Boettcher präpariert ist. Im Folgenden gebe ich daher nur die Beschreibung der neuen Arten.

Parastasia incurva sp. nov. Tafel 1, Fig. 1.

Der *P. femorata* Burmeister von Java zunächst verwandt, von derselben Körperform, aber meist etwas grösser und durch die grobe Punktierung des Thorax gut unterschieden. Kopf und Kopfschild sind ziemlich dicht, aber fein und seicht punktiert, der Thorax dagegen mit grossen Ringpunkten dicht bedeckt, ebenso tragen die Deckflügel Reihen grosser Ringpunkte, während das Schildchen nur wenige feine Pünktchen trägt. Die nahe verwandte *indica* Ohaus hat ganz ähnliche Färbung und ebenfalls grobe Sculptur des Thorax, aber auf den Deckflügeln feine, nach hinten verloschene Punktreihen. Der Forceps (Tafel 1, Fig. 1), ist ganz verschieden von dem der *indica,* aber ähnlich dem der *femorata,* jedoch ist das Mittelstück dicker und kürzer, die Parameren sind ganz asymmetrisch, beide mit einander verwachsen, die rechte grösser als die linke, nach hinten und links gekrümmt. Länge, 12–14 Millimeter; Breite, 6 bis 7. Männchen, Weibchen.

[1] Philip. Journ. Sci. § D 5 (1910) 233–262.
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LUZON, Kalinga, Balbalan, 30ter Januar, 1917. MASBATE, Aroroy, 17ter August, 1917 (*G. Boettcher*).

Bei dem Männchen von Masbate sind Teile des Thorax sowie die Schenkel und Hüften rotgelb, das übrige schwarz, bei dem Weibchen von Masbate nur die Hinterecken des Thorax rotgelb; Stücke von Balbalan schwarz bis rotgelb. Die Art ist vielleicht so variabel in der Färbung wie die *femorata.*

Anomala sibuyana sp. nov.

Aus der Verwandtschaft der *flavoscutellata* Ohaus von Nord-Luzon. Gestreckt eiförmig, hinten leicht verbreitert. Färbung veränderlich von scherbengelb mit schwarzbrauner Zeichnung auf Kopf, Thorax, Schildchen, Rändern der Deckflügel und Tarsen, bis schwarzbraun mit scherbengelben Rändern des Thorax, Unterseite, Schenkel und Schienen ebenfalls gelb. Clipeus trapezförmig, die Ecken wenig gerundet, fein runzelig punktiert; Kopf, Thorax, und Schildchen fein und dicht, vielfach zusammenfliessend punktiert. Auf den Deckflügeln sind die primären Punktreihen regelmässig gefurcht, die Punkte gross, ringförmig, kräftig eingedrückt, im subsuturalen Intersititium steht eine Punktreihe die in der vorderen Hälfte unregelmässig verdoppelt ist mit einigen kurzen Querrunzeln dazwischen. Pygidium dicht bedeckt mit in die Quere gezogenen Ringpunkten, die bogenförmig in die Spitze vor der Afteröffnung angeordnet sind und vielfach seitlich zusammenfliessen. After, Unterseite, und Beine mit einigen wenigen gelben Haaren. Vorderschienen mit einem deutlichen Seitenzahn. Fühlerkeule immer gelb, beim Männchen nicht verlängert. Am Forceps ist das Mittelstück lang, gewölbt, die kurzen Parameren symmetrisch, die Ventralplatte des Mittelstückes mit einem kurzen hakenförmigen Fortsatz am Hinterrand. Länge, 7.5 Millimeter. Männchen und Weibchen.

SIBUYAN (*Baker*).

Anomala melitta sp. nov.

Der A. *leotaudi* Blanchard zunächst verwandt. Vorderkörper, Deckflügel, und Beine hell scherbengelb mit braunen Flecken, glänzend, der ganze Hinterleib dunkelbraun, matt. Kopf und Vorderrücken dicht und ziemlich kräftig punktiert, der letztere mit zwei braunen Flecken auf der Scheibe. Deckflügel mit zwei unregelmässigen Querbinden von Flecken, eine an der Basis, die andere am Hinterrand; die primären Punktreihen sind tief gefurcht, Rippen und Interstitien gleich hoch gewölbt, im subsuturalen Interstitium zwei secundäre Rippen, die nahe der

Basis breiter getrennt sind, im zweiten und dritten Interstitium nur je eine seichtere Punktreihe. Bauchringe und Brust grauweis behaart. Forceps klein, ohne Besonderheiten. Länge, 10.5 Millimeter; Breite, 5.5. Männchen.

MINDANAO, Surigao, Surigao (*Baker 17041*).

Anomala surigana sp. nov. Tafel 1, Fig. 2.

Die Art steht in der Mitte zwischen *A. catenatopunctata* Ohaus und *heteroglypha* Ohaus, hat die Gestalt und Färbung der ersteren, aber eine Sculptur ähnlich derjenigen der letzteren. Erzgrün, glänzend poliert, Kopf, Thorax, und Seiten der Deckflügel hell kupferschillernd. Der Kopf ist zusammenfliessend, Stirn, Scheitel, Prothorax, und Schildchen mässig dicht einzeln punktiert, alle Punkte fein und seicht; die basale Randfurche des Thorax nicht unterbrochen; Seitengrübchen vorhanden. Auf den Elytren sind die primären Punktreihen scharf eingerissen, die Punkte deutlich ringförmig, alle einzeln; das subsuturale Interstitium enthält eine Punktreihe, die von der Basis bis zum letzten Drittel doppelt ist; die zwei discalen Interstitien enthalten je eine einfache Punktreihe; die seitlichen sind punktfrei; Schultern und Spitzenbuckel springen stark vor und sind glatt. Afterdecke sehr fein und dicht nadelrissig, wenig glänzend, nur am Rand mit einigen rötlichen Haaren. Unterseite fast kahl, nur die Brust spärlich und kurz grau behaart. An den Vorderschienen ist der Seitenzahn sehr kurz, die Mittel- und Hinterschienen sind verdickt. Der Forceps (Tafel 1, Fig. 2) ist ähnlich dem der *catenatopunctata*. Länge, 12.5 Millimeter; Breite 6.75. Männchen.

MINDANAO, Surigao, Surigao (*Baker*).

Anomala butuana sp. nov. Tafel 1, Fig. 3.

Nahe verwandt der *A. exarata* Burmeister, die nach Burmeister auch auf Luzon vorkommen soll, die ich aber nur von Celebes kenne. Gestreckt eiförmig, dunkelbraun mit erzgrünen und kupfrigen Lichtern, oben kahl, unten graugelb behaart. Der Kopf ist dicht und fein runzelig punktiert, Thorax und Schildchen mit grösseren Ringpunkten, an den Seiten dicht, in der Mitte mehr einzeln bedeckt, basale Randfurche in der Mitte breit unterbrochen. Auf den Deckflügeln sind die primären Punktreihen regelmässig gefurcht, die Punkte grob und vielfach quer eingedrückt, primäre Rippen und Interstitien respektiv secundäre Rippen gleich hoch gewölbt; im subsuturalen Interstitium stehen zwei secundäre Rippen und zwischen diesen eine tertiäre, die besonders beim Weibchen in ihrer vorderen

Hälfte abgeflacht und in eine unregelmässige Punktierung aufgelöst ist; im zweiten und dritten Interstitium stehen je zwei regelmässige secundäre Rippen; die vierte primäre Rippe aussen neben der unregelmässig punktierten vorspringenden Schulter ist in ihrem vorderen Teil verloschen, im weiteren Vorlauf nach hinten etwas verbreitert und stärker gewölbt. Afterdecke und Unterseite dicht und fein gerunzelt. Vorderschienen mit einem kräftigen Seitenzahn, Mittel- und Hinterschienen ohne Auszeichnung. Der Forceps (Tafel 1, Fig. 3) hat einige Aehnlichkeit mit dem der *A. cucusa,* doch ist bei dieser Art die Sculptur der Deckflügel eine ganz andere. Länge, 13 bis 14 Millimeter; Breite, 7 bis 7.5. Männchen und Weibchen.

MINDANAO, Agusan, Butuan (*Baker*).

Anomala volanda sp. nov. Tafel 1, Fig. 4.

Aus der Gruppe der *A. humeralis.* Kopf, Schildchen, und Halsschild schwarzbraun mit erzgrünen und kupfrigen Lichtern, lebhaft glänzend, das letztere mit einem grossen rotgelben Fleck jederseits, dicht und ziemlich kräftig punktiert. Deckflügel rotgelb mit feinem schwarzem Seitenrand, die primären Punktreihen regelmässig gefurcht, Rippen und Interstitien gleich hoch gewölbt, die drei discalen Interstitien mit je zwei secundären Rippen, im subsuturalen Interstitium zwischen den secundären Rippen von der Basis bis zur Mitte eine schmale tertiäre. Afterdecke dicht und fein runzelig, schwarzbraun mit sechs scharf begrenzten rotgelben Makeln, vier in der basalen Reihe, zwei an der Spitze. Unterseite und Beine schwarzbraun, die Mittel- und Hinterschenkel nahe dem Knie sowie die Epimeren der Mittelbrust mit einem rotgelben Fleck. Rand der Afterdecke und Brust graugelb behaart. Am Forceps tragen die Parameren an der Spitze je einen zangenartig gekrümmten asymmetrischen Fortsatz (Tafel 1, Fig. 4.). Länge, 14.5 Millimeter; Breite, 8. Männchen.

MINDANAO, Surigao, Surigao (*Baker 17042*).

Anomala macrophalla sp. nov. Tafel 1, Fig. 5.

Zur Gruppe der *A. windrathi* Nonfried gehörig und in dieser der *A. camarinensis* Ohaus zunächst verwandt. Gestreckt oval, hinten nicht verbreitert, oben rotbraun, Kopf, Vorderrücken, und Schildchen mit Kupferglanz, die Nahtrippen leicht erzgrün, Unterseite und Beine schwarzbraun mit grünem Schiller, die Seiten der Bauchringe und die Afterdecke rot, die letztere mit schwarzbrauner Zeichnung; Oberseite und Afterdecke kahl, Brust und Hüften gelb behaart. Kopf, Vorderrücken, und Schildchen

sind dicht und ziemlich kräftig, vielfach zusammenfliessend punktiert. Auf den Deckflügeln sind die primären Punktreihen kräftig gefurcht, die Punkte kräftig eingedrückt, dicht hintereinander stehend, halbkreis- bis kreisförmig, die primären Rippen breiter als die secundären, von letzteren in den discalen Interstitien je zwei, in den lateralen je eine stehend; die zwei secundären Rippen im subsuturalen Interstitium sind in der vorderen Hälfte getrennt dadurch, dass die Punktreihe hier sich verdoppelt mit einigen wenigen unregelmässigen Punkten dazwischen; im zweiten Interstitium ist die trennende Punktreihe zwischen den zwei secundären Rippen nur an der Basis für zwei oder drei Punkte verdoppelt. Afterdecke dicht und fein querrissig mit gröberen Runzeln an den Seiten. Bauchringe in der Mitte weitläufig, an den Seiten dichter Punktiert.

Die Forceps (Tafel 1, Fig. 5) ist ähnlich dem der *A. hamigera* Ohaus,[4] der lappenartige Fortsatz der Parameren aber noch grösser, bis zur Spitze reichend, die oberen Spitzen stärker umgebogen; die Ventralplatte des Mittelstückes mit scharfer Spitze, hakenförmig nach unten gebogen. Länge, 17 Millimeter; Breite, 8.5. Männchen.

MINDANAO, Zamboanga, Dapitan (*Baker*).

Anomala polina sp. nov.

Der *A. camarinensis* Ohaus zunächst verwandt. Gestreckt eiförmig, leicht gewölbt, dunkelbraun mit leichtem grünem Erzschimmer—bei einem ausgefärbtem Stück rotbraun—die Seiten des Halsschildes, die Deckflügel, und die Schenkel rötlich gelb. Kopfschild und Stirn sind dicht runzelig, Scheitel, Halsschild, und Schildchen ziemlich dicht aber einzeln mit grossen groben Punkten bedeckt, glänzend. Auf den Deckflügeln sind die primären Punktreihen gefurcht, Rippen und Interstitien gewölbt, im subsuturalen Interstitium zwei secundäre und dazwischen eine tertiäre Rippe, die zweite und dritte primäre Rippe tragen einzelne grobe Punkte. Afterdecke grob höckerig, nur an der Spitze und an den Seiten mit langen rotbraunen Borsten. Bauchringe und Brust sehr grob punktiert, die letztere dicht rotgelb behaart. Länge, 17 Millimeter; Breite, 10. Männchen.

LUZON, Ifugao, Mount Polis, Februar, 1917 (*G. Boettcher*).

Anomala samarensis sp. nov. Tafel 1, Fig. 6.

Der *A. camarinensis* Ohaus sehr nahe verwandt, etwas grösser, durch die Färbung and die Sculptur der Deckflügel unter-

[4] Stettiner Ent. Zeitg. (1915) 127, Fig. 12.

schieden. Kopf, Vorderrücken, und Schildchen dunkelbraun mit erzgrünen oder kupfrigen Lichtern, Kopfschild und Seiten des Vorderrückens rotgelb, alle drei dicht und kräftig punktiert. Deckflügel rötlich scherbengelb, heller als bei der *camarinensis*, die zweite primäre Rippe (zwischen Naht und Schulter) im mittleren Drittel mit doppelter Punktreihe; im subsuturalen Interstitium steht zwischen den zwei secundären Rippen eine tertiäre, die nahe der Basis durch unregelmässige Punkte undeutlich ist. Afterdecke rotgelb mit dunklem Längsstreifen in der Mitte und einem dunklen Punkt jederseits neben der Spitze, überall sehr grob punktiert. Unterseite veränderlich, entweder rotgelb mit dunklen Flecken oder dunkel braungrün mit gelben Fleckchen an den Seiten, die Schenkel und die vorderen Schienen innen stets rotgelb. Forceps, Tafel 1, Fig. 6. Länge, 14.5 bis 15.5 Millimeter; Breite, 8 bis 8.5. Männchen und Weibchen.

SAMAR, Juni–Juli, 1896 (*J. Whitehead*).

Von Mindanao: Surigao, Surigao und Agusan, Butuan (*C. F. Baker*) liegt mir je ein Exemplar (No. 18550 und 18547) einer Form vor, die wohl nur als eine Localform der *A. samarensis* zu betrachten ist. Sie stimmt in allen wesentlichen Merkmalen mit dieser überein, weicht aber in der Sculptur der Deckflügel in der Weise ab, das bei dem Surigao-Stück die zweite primäre Rippe von der Basis bis zum letzten Drittel eine doppelte Punktreihe trägt, während sie bei dem Butuan-Stück fast im ganzen Verlauf glatt ist und nur im mittleren Drittel drei oder vier Punkte trägt.

Anomala cucusa sp. nov.

Aus der Verwandtschaft der *A. dapitana* Ohaus und *A. despumata* Ohaus und *A. fuscula* Sharp, grösser und breiter, die ganze Oberseite dichter und gröber punktiert und daher weniger glänzend; oben und unten erzgrün, oben kahl, Afterdecke und Brust dicht abstehend graugelb, die Bauchringe in der Mitte spärlich, an den Seiten büschelförmig behaart. Auf den Deckflügeln ist nur die Nahtrippe glatt, die sie begrenzende Punktreihe regelmässig, alle Interstitien sind dicht punktiert, die Sculptur durch feine Querrunzeln unübersichtlich. Afterdecke dicht und fein nadelrissig. Der Seitenzahn der Vorderschienen ist beinahe verloschen, die Mittel- und Hinterschienen wenig verdickt.

Der Forceps ist ähnlich dem der genannten Arten, auch dem der *A. hopei* Kirsch, *A. waterstraati* Ohaus, und *A. cobala* Ohaus, und hat an der Rutenblase (Penis) einen dichten Büschel von starren Borsten.

Länge, 14.5 bis 16 Millimeter; Breite, 8.5 bis 9. Männchen und Weibchen.

MINDANAO; Surigao, Surigao, 4ten November, 1925 (*Boettcher, Baker*).

Anomala calpurnia sp. nov. Tafel 1, Fig. 7.

Zur Gruppe der *A. chlorotica* Guérin gehörend und in dieser der *A. cassiana* Ohaus zunächst stehend. Kleiner, elliptisch, ziemlich gewölbt, Oberseite scherbengelb, der ganze Kopf, die vordere Hälfte und die Ränder des Thorax, Schildchen und Ränder der Deckflügel, Afterdecke, Unterseite, Beine, und Fühler schwarzbraun. Oberseite kahl, Afterdecke und Brust anliegend grau behaart, die Seiten der Bauchringe mit kleinen Haarbüscheln. Kopf und Halsschild mit ziemlich flachen Ringpunkten mässig dicht, Schildchen dichter und gröber punktiert. Auf den Deckflügeln sind die primären Punktreihen deutlich gefurcht, das subsuturale Interstitium mit unregelmässigen Punktreihen, die zweite primäre Rippe zum Teil mit gereihten Punkten, zum Teil punktfrei, das zweite und dritte Interstitium mit je zwei Punktreihen, die dritte primäre Rippe punktfrei. Unterseite und Beine wie bei der *A. cassiana;* der Forceps (Tafel 1, Fig. 7) ist kleiner, die Parameren gleich gross.

Länge, 11 Millimeter; Breite, 6. Männchen.

POLILLO, bei LUZON (*Baker*).

Anomala cassiana sp. nov. Tafel 1, Fig. 8.

Der *A. chlorotica* Guérin zunächst verwandt. Gestreckt elliptisch, mässig gewölbt. Oben leicht rötlich scherbengelb ohne allen Metallschiller, Schultern und feiner Saum der Deckflügel dunkelbraun; Unterseite und Afterdecke, Beine und Fühler kastanienbraun. Oberseite kahl, Bauch und Beine spärlich, Afterdecke und Brust dicht und anliegend graugelb behaart, die Seiten der Bauchringe mit Haarbüscheln. Kopfschild sehr kurz, fast dreimal so breit als lang, mit ziemlich stark gerundeten Vorderecken, die Fläche wie die Stirn dicht mit zusammenfliessenden Ringpunkten bedeckt. Auf dem Halsschild sind diese Ringpunkten etwas grösser, an den Seiten dicht zusammenfliessend, auf der Scheibe nur wenig sperriger; die Basale Randfurche ist nicht unterbrochen. Schildchen wie Halsschild punktiert. Auf den Deckflügeln sind die primären Rippen nicht gewölbt, von den primären Punktreihen ist nur die erste, neben der Nahtrippe, ganz erhalten, von der zweiten bis sechsten nur kurze Reste nahe dem Hinterrand erhalten, alles übrige ist mit unre-

gelmässigen, dichten Punktreihen bedeckt; im subsuturalen Interstitium etwa sechs, nur die Seiten sind wie gewöhnlich etwas weniger punktiert. Vorderschienen mit kurzen Spitzenzahn, beide Seitenzähne verloschen; Mittel- und Hinterschienen leicht verdickt, ganz ohne schiefe Stachelkanten. Der Forceps (Tafel 1, Fig. 8) ist ähnlich dem der *A. brachycaula* von Celebes, die rechte Paramera grösser als die linke. Länge, 12.5 Millimeter; Breite, 6.5. Männchen.

MINDANAO, Zamboanga, Dapitan (*Baker*).

Anomala metella sp. nov. Tafel 1, Fig. 9.

Der *A. cuprascens* Wiedemann von Java und Sumatra zunächst verwandt, von derselben Körperform, Grösse, und Färbung, aber verschieden durch die Sculptur der Deckflügel. Wie auf Kopf, Thorax, und Schildchen ist auch auf den Elytren die Punktierung feiner und seichter als bei der *cuprascens,* die primären Punktreihen sind nicht gefurcht, die primären Rippen nicht höher als die Interstitien, ganz punktfrei; das subsuturale Interstitium ist unregelmässig punktiert bis zum Hinterrand, im zweiten Interstitium steht eine einfache, nur vorn und hinten kurz verdoppelte Punktreihe. Propygidium und Pygidium sind dicht und fein querrissig, Unterseite und Beine wie bei der *cuprascens,* die Fühlerkeule etwas länger. Forceps, Tafel 1, Fig. 9. Länge, 14 Millimeter; Breite, 7.5. Männchen.

BORNEO, Sandakan (*Baker*).

Malaia stigma sp. nov.

Der *M. thoracica* Ohaus ähnlich. Kopf, Vorderrücken, und Schildchen erzgrün, dicht und fein runzelig punktiert, stellenweise nadelrissig, wenig glänzend; die Stirn dreiseitig abgeflacht; Thorax ohne Seitengrübchen, ohne basale Randfurche, ohne glatte Schwiele beim Hinterrand. Deckflügel abgeflacht mit stark vorspringenden Schultern und flachen Spitzenbuckeln, die primären Punktreihen scharf gefurcht, die Punkte gross, ringförmig; die Grundfarbe ist entweder rein hell rotbraun, oder rotbraun mit schwarzbraunem breitem Seitenrand und braunem Fleckchen direkt hinter dem Schildchen und nahe dem Hinterrand; im subsuturalen Interstitium steht auf der inneren secundären Rippe ein kleines hellgelbes Fleckchen. Die ganze Oberseite ist kahl, die hintere Hälfte des Propygidium, das Pygidium ganz, der Leib und die Brust dicht mit gelben Schuppenhaaren bekleidet. An Vorder- und Mittelbeinen sind Schenkel und Schienen, an den Hinterbeinen nur die Schenkel hellgelb mit grünem Erzschiller, die Hinterschienen und alle

Tarsen dunkel erzgrün. Fühler schwarzbraun mit hellerer Geissel.

Der Forceps ist ähnlich dem der *Pseudomalaia flavopilosa* Ohaus von Negros, welche Art den Uebergang zwischen *Malaia* und *Popillia* bildet. Länge, 8 bis 8.5 Millimeter; Breite, 4.5 bis 5.

MINDANAO, Surigao, Surigao (*Boettcher, Baker*).

Popillia nona sp. nov. Tafel 1, Fig. 10.

Der *P. depressa* Kraatz zunächst verwandt, von derselben Körperform und Grösse. Kopf und Kopfschild hell erzgrün, glänzend, dicht und kräftig runzelig punktiert. Thorax hell bräunlichgelb mit einer grossen dunkeln Makel, erzgrün schillernd, mit grossen zusammenfliessenden Ringpunkten dicht bedeckt. Schildchen braungelb mit dunklem Rand, dicht grob punktiert. Deckflügel bräunlichgelb mit dunklem Seitenrand und Schultermakel, an der Basis und hinter dem Schildchen mit kleiner weissgelber Makel, die primären Punktreihen ganz seicht gefurcht. Afterdecke mit seichten weitläufigen Querrissen und grossen gelblichen Haarbüscheln, die an der Basis zusammenstossen. Unterseite dicht gelblich behaart. Beine bräunlichgelb mit schwarzbraunen Tarsen. Forceps, Tafel 1, Fig. 10. Länge, 7 bis 7.5 Millimeter; Breite, 4. Männchen and Weibchen.

MINDANAO, Surigao, Surigao (*Baker 17038*).

Popillia alticola sp. nov.

Der *P. conopyga* Ohaus zunächst verwandt, kleiner. Oval, abgeflacht, entweder rein dunkelblau oder die Deckflügel mit rötlichgelber Scheibe, mässig glänzend. Kopf und Vorderrücken dicht und grob, vielfach zusammenfliessend punktiert, der letztere ohne Seitengrübchen, ohne basale Randfurche, mit scharf ausgezogenen Ecken, nach innen vom Ort des Seitengrübchens flach vertieft, der Seitenrand mit längeren gelben oder weissen Haaren, die an den Ecken kurz auf Vorder- und Hinterrand übergehen. Schildchen mit wenigen seichten Punkten. Die Deckflügel sind auf der Scheibe hinter dem Schildchen tief eingedrückt, die Schultern springen kräftig, die Spitzenbuckel weniger vor, die primären Punktreihen sind tief gefurcht. Afterdecke breit gewölbt, mit einzelnen groben Ringpunkten, an der Basis zwei grosse Haarbüschel und ausserdem der Seitenrand mit langen Haaren, die vor den Ecken der Afteröffnung zu kleineren Büscheln verdichtet sind. Bauchringe mit langen Haaren, die vom Vorderrand entspringen; Brust, Hüften, und Schenkel ziemlich dicht behaart. Klauenglied gezähnt, die grössere Klaue an allen Füssen lang. Der Forceps ist stark

verschieden von dem der *conopyga*. Länge, 7.5 bis 8 Millimeter; Breite, 4.5. Männchen.

LUZON, Nueva Vizcaya, Imugan, Juni, 1916 (*Boettcher*): Benguet, Baguio (*Baker*).

Adoretus speculator sp. nov.

Zur Gruppe des *A. luridus* Blanchard gehörend. Gestreckt parallel, flach gewölbt, oben ziemlich dunkel rotbraun, Kopfschild und Elytren sowie die Unterseite und Beine etwas heller, überall gleichmässig sperrig fein graugelb behaart. Der Kopf ist sehr gross, besonders die Augen, Stirn und Scheitel länger als der Clipeus, dessen parabolischer Rand kräftig aufgebogen ist. An der Oberlippe ist das Rostrum lang, schmal, glänzend schwarz, kaum gekerbt. Thorax wohl dreimal so breit als lang, wie der Kopf einzeln seicht punktiert. Auf den Elytren sind die primären Punktreihen gefurcht, die Punkte kräftig, dichtstehend, die Interstitien feiner punktiert. Afterdecke länger abstehend gelb behaart. An den Vorderschienen stehen die drei spitzen Zähne in gleichem Abstand, Mittel- und Hinterschienen haben nur je eine lange schiefe Stachelkante. Fühlerkeule fast so lang als die Geissel. Länge, 9 Millimeter; Breite, 5. Männchen.

BORNEO, Sandakan (*Baker*).

Chaetadoretus bakeri sp. nov.

Dem *C. trichostigma* Ohaus von Nord Borneo zunächst verwandt, aber in folgenden Punkten verschieden. Etwas grösser, hell scherbengelb, leicht glänzend, sperrig weiss behaart mit zwei bräunlichen Flecken auf dem Thorax. Clipeus rötlichgelb, fein und spärlich punktiert, Stirn und Scheitel gröber und dichter. Auf den Deckflügeln sind alle primären Rippen deutlich ausgeprägt und höher gewölbt als die Interstitien, die Spitzenbuckel vorspringend, glatt, gelblich, die Partie dahinter bräunlich, nur mit einem kleinen Büschel weisser Haare, nicht mit einer Querbinde, wie bei der *C. trichostigma*. An den Vorderschienen sind die Zähne kräftig, schwarzbraun, der mittlere dem Spitzenzahn genähert. Mittel- und Hinterschienen verbreitert und verdickt, die basale der beiden Stachelkanten fast verloschen. Am Forceps sind die Parameren in zwei ziemlich lange braune Spitzen ausgezogen. Länge, 11 Millimeter; Breite, 6. Männchen.

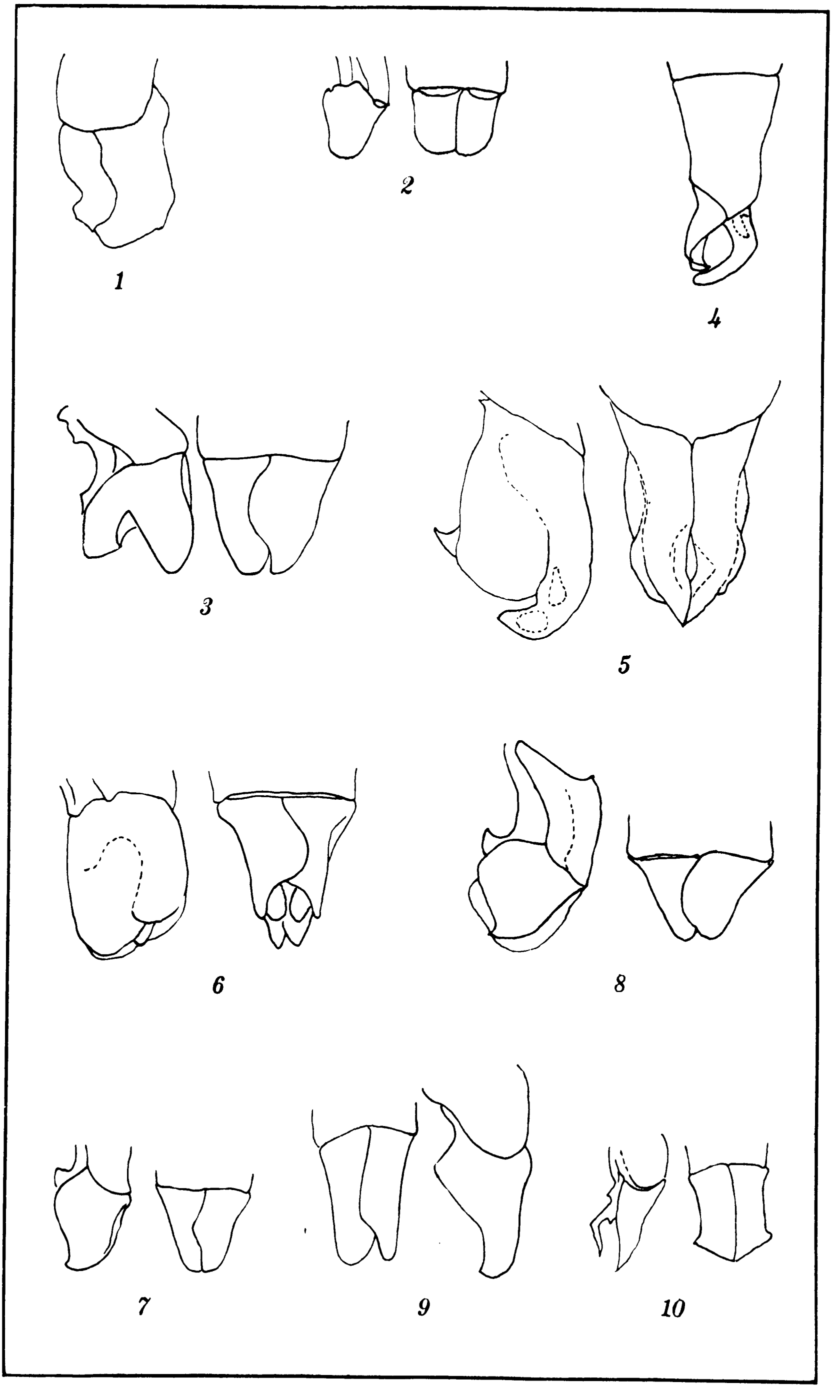
BASILAN (*Baker*).

TAFELERKLÄRUNG

TAFEL 1. FORCEPS DER RUTELIDEN

FIG. 1. *Parastasia incurva* sp. nov.
2. *Anomala surigana* sp. nov.
3. *Anomala butuana* sp. nov.
4. *Anomala volanda* sp. nov.
5. *Anomala macrophalla* sp. nov.
6. *Anomala samarensis* sp. nov.
7. *Anomala calpurnia* sp. nov.
8. *Anomala cassiana* sp. nov.
9. *Anomala metella* sp. nov.
10. *Popillia nona* sp. nov.

192375——3



TAFEL 1.

NEW MALAYAN WASPS OF THE SUBFAMILY PSENINÆ

By S. A. ROHWER

Honorary Custodian of Hymenoptera, United States National Museum

In a recent paper [1] I described fourteen species of psenid wasps from the Philippines. Since that paper was prepared, Prof. C. F. Baker has forwarded other species of the subfamily Pseninæ; most of these were undescribed, and many of them came from the Philippines. With the descriptions here presented the number of Philippine species of this subfamily totals twenty-one, a very creditable number considering the area of the Islands. More collecting will, however, undoubtedly produce additional undescribed forms, and field observations will aid greatly in associating sexes.

Genus **DIODONTUS** Curtis

The following three new species run to couplet 6 in my key [2] and may be separated as follows:

6. Petiole longer than hind femora, concolorous with gaster; area outside lateral ocelli depressed .... **D. philippinensis** Rohwer.
   Petiole subequal in length with hind femora, concolorous with gaster; area around ocelli not depressed; no transverse carina on face. **D. penangensis** sp. nov.
   Petiole black; area around ocelli not depressed; a transverse carina below antennæ .... 6 a.

6 a. Petiole not sharply separated from rest of tergite; inclosure of propodeum longer and with strong carinæ; face narrower. **D. dapitanensis** sp. nov.
   Petiole sharply separated from rest of tergite; propodeal inclosure shorter and with close carinæ; face broader .... 6 b.

6 b. Antenna slender, the joints not rounded out; face not strongly narrowing; propodeum beyond inclosure punctured. **D. basilanensis** Rohwer.
   Antenna with joints rounded out; eyes strongly converging below; dorsal part of propodeum smooth .... **D. antennatus** sp. nov.

Diodontus penangensis sp. nov.

Female.—Length, 6.5 millimeters. Clypeus convex, the anterior margin bidentate medianly; face closely punctured, convex

[1] Philip. Journ. Sci. **18** (1921) 309. Separates received in Washington, August 4, 1921.

[2] Philip. Journ. Sci. **18** (1921) 310.

at end of frontal carina but without a transverse carina; eyes closest together just below antennæ; frons with close distinct punctures; vertex with widely scattered punctures; ocelli in an obtuse triangle; postocellar line subequal with ocellocular; antennæ short, stout, distinctly thickening apically, third joint somewhat longer than fourth; pronotum strongly carinate anteriorly, the lateral angles rounded; scutum shining, very sparsely punctured; notauli indicated on anterior half of scutum; suture in front of scutellum feebly foveolate; scutellum shining with a few punctures; dorsal area of propodeum shining, with a wide depressed area medianly which connects posteriorly with the deep channel and anteriorly with the nearly linear, foveolate basal area; posterior face of propodeum coarsely reticulate, the sides nearly smooth; mesepisternum polished, the suture strongly foveolate; petiole strongly curved, cylindrical, subequal in length with hind femora, distinctly separated from rest of tergite; gaster polished; first recurrent received near base of second cubital cell; second recurrent sinuate, joining third cubital cell a distance equal to about half the length of second intercubitus from base of cell; second cubital cell about three times as long on cubitus as on radius. Black; scape, basal joints of antennæ, and flagellum beneath rufopiceous; tubercules and tegulæ testaceous; abdomen dark rufous; tibiæ and tarsi testaceous; head and thorax with dense silvery hair; wings hyaline, venation dark brown.

Type locality.—Penang Island.

Described from one female received from C. F. Baker.

Type.—Catalogue No. 25037, United States National Museum.

Diodontus dapitanensis sp. nov.

Female.—Length, 9 millimeters. Clypeus very gently convex, the anterior margin truncate; face finely coriaceous, with an incomplete transverse ridge, which medianly joins frontal carina; eyes closest together opposite antennæ, the area between eyes narrow; frons and vertex polished; lateral ocelli in pits; ocelli in an obtuse triangle; postocellar line shorter than ocellocular line; antennæ extending a little beyond hind margin of tegulæ, thickening apically, third joint longer than fourth; anterior margin of pronotum sharp, the lateral angles sharp; scutum shining, with well-separated punctures; notauli evident for about three-fourths the length of scutum; suture in front of scutellum not foveolate; scutellum shining, with sparse setigerous punctures; metanotum hairy; dorsal area of propodeum polished, the inclosure triangular and with strong rugæ; posterior face

of propodeum coarsely reticulate, the channel deep and foveolate; mesepisternum polished, the suture foveolate; sides of propodeum coarsely reticulate; petiole cylindrical, strongly curved basally, not sharply separated from rest of tergite; gaster polished; pygidium not defined, pygidial area finely granular; first recurrent received very close to end of first cubital cell; second recurrent sinuate, received by third cubital a distance about equal to one-third the length of second intercubitus from base of cell; second cubital cell about twice as long on cubitus as on radius. Black; mandibles, scape, tubercules, legs, and base of petiole yellowish; tegulæ and flagellum (except above) testaceous; central area of first tergite black; apex of first tergite and all of following segments rufous; head and thorax with dense silvery hair; wings hyaline, venation testaceous.

Type locality.—Dapitan, Mindanao.

Described from one female received from C. F. Baker.

Type.—Catalogue No. 25038, United States National Museum.

Diodontus basilanensis Rohwer.

A female from Sandakan, Borneo, agrees with the type and is returned to the sender, C. F. Baker. A male collected at Singapore certainly belongs to this species and agrees well with the description of the female.

Diodontus antennatus sp. nov.

Male.—Length, 7 millimeters. Anterior margin of clypeus bidentate medianly; face finely coriaceous; transverse carina incomplete and where it joins frontal carina arched dorsally; eyes closest together opposite antennæ; frons shining, with well-separated, distinct punctures; vertex with the punctures more widely separated; area around ocelli not depressed; ocelli in a low triangle; postocellar line as long as ocellocular; antennæ long, moniliform, third joint longer than fourth; anterior margin of pronotum sharply carinate and slightly dentate laterally; scutum shining, very sparsely punctured; notauli indicated anteriorly; suture in front of scutellum foveolate; scutellum shining; metanotum hairy; dorsal area of propodeum polished, depressed medianly, the depression connecting anteriorly with the linear foveolate inclosure and posteriorly with the deep channel; posterior face of propodeum coarsely reticulate; mesepisternum shining, with scattered setigerous punctures, the suture foveolate; sides of propodeum shining; petiole cylindrical, strongly curved, subequal in length with hind femur, distinctly separated from rest of tergite; gaster polished; first recurrent

received by second cubital close to base; second recurrent sinuate below, received by third cubital a distance about equal to half the length of second intercubitus from base of cell; second cubital cell more than twice as long on cubitus as on radius. Black; scape, flagellum beneath, tubercules, and tegulæ testaceous; trochanters, four anterior femora above, all tibiæ and tarsi yellowish with some brownish infuscations; gaster rufous; head and thorax with usual silvery hair; wings hyaline, venation dark brown.

Type locality.—Singapore, Straits Settlements.

Described from one male received from C. F. Baker.

Type.—Catalogue No. 25039, United States National Museum.

Diodontus scutatus Rohwer.

In the material examined are two new color varieties of this species which may be distinguished by the following key:

1. Mesepisternum and sternum entirely pale; gaster ferruginous; scutum mostly pale .... **D. scutatus** var. **scutatus** Rohwer.
   Mesepisternum mostly and sternum entirely black .... 2.
2. Mesepisternum with a yellow line below; anterior part of scutum yellow; gaster rufous .... **D. scutatus** var. **mindanaoensis** var. nov.
   Mesepisternum entirely black; anterior part of scutum black; gaster piceous .... **D. scutatus** var. **borneensis** var. nov.

Diodontus scutatus var. **borneensis** var. nov.

Female.—Length, 7.5 millimeters. Because of the dark gaster this superficially resembles *Diodontus xanthognathus* Rohwer, but it differs markedly from that species. The scutum, except a quadrate spot before the scutellum and the narrow lateral margins, is black. Mesepisternum (except spot below tegula) and sternum black; metapleura black; gaster piceous; otherwise colored like the typical form.

Type locality.—Sandakan, Borneo.

Described from one female received from C. F. Baker.

Type.—Catalogue No. 25040, United States National Museum.

Diodontus scutatus var. **mindanaoensis** var. nov.

Female.—Length, 8.5 millimeters. Differs from the type in the following color characters: Black spot on the scutum larger, covering most of the surface; base and apex of propodeum black; mesepisternum, except prepectus and a narrow longitudinal ventral line, and mesosternum black; metapleuron black.

Type locality.—Iligan, Mindanao.

Described from a single female received from C. F. Baker.

Type.—Catalogue No. 25041, United States National Museum. This may possibly be the female of variety A.

Diodontus bakeri Rohwer.

A female from Iligan, Mindanao, has been examined and returned to the sender, C. F. Baker.

Diodontus ajax Rohwer.

A female from Singapore forwarded by C. F. Baker is smaller than the type (length 9.5 millimeters), has the black of the thorax more extensive, and has the petiole rufous.

The following five species, known only from the male, run to *D. ajax* Rohwer in my key.[3] None of them agree with any of the females examined and until the antigeny of this group is better understood they would best be given separate names. They may be separated as follows:

1. Posterior face of propodeum smooth, without sculpture; scutum yellow, with a single black spot .... **D. sandakanensis** sp. nov.
   Posterior face of propodeum coarsely sculptured; scutum with at least three black spots .... 2.
2. Flagellar joints cylindrical, not rounded out beneath. **D. filicornis** sp. nov.
   Flagellar joints 5 to 12 rounded out beneath .... 3.
3. First recurrent received in second cubital cell; scutum with three black spots .... **D. davanus** sp. nov.
   First recurrent received in first cubital cell; scutum with three black lines .... 4.
4. Third and fourth antennal joints subequal; petiole unicolorous. **D. ajaxellus** sp. nov.
   Third joint distinctly longer than fourth; apex of petiole black. **D. esuchus** sp. nov.

Diodontus sandakanensis sp. nov.

Evidently closely allied to *Diodontus interstitialis* (Cameron). It differs from the description of *Psen lutescens* Turner, which is said to be a synonym, in having the first recurrent received near apex of first cubital cell and in having the base of petiole yellow.

Male.—Length, 5.5 millimeters. Clypeus convex, the apical margin with two small median teeth; face shining, with close setigerous punctures; the transverse ridge below antennæ rounded laterally and joining antennal fossæ; frons smooth; ocelli in a low triangle; postocellar line much shorter than ocellocular line; antennæ slender, third joint longer than fourth, joints 5 to 12 slightly rounded out beneath; thorax smooth; suture in front of scutellum finely foveolate; propodeal inclosure broadly triangular in outline, with ten slightly oblique

[3] Philip. Journ. Sci. 18 (1921) 310.

rugæ, the median ones somewhat stronger; second cubital cell twice as long on cubitus as on radius; first recurrent received near apex of first cubital cell; petiole shorter than hind femora, slightly wider posteriorly; abdomen smooth and shining. Yellow; head except mandibles, flagellum except basal joints beneath, a small spot in center of scutum, suture in front of scutellum, inclosure of propodeum, prepectus, sternum, metapleuron, and apex of petiole black; abdomen beyond petiole rufous; wings hyaline; venation pale brown; head with silvery hair.

Type locality.—Sandakan, Borneo.

Described from one male received from C. F. Baker under his number 16829.

Type.—Catalogue No. 25042, United States National Museum.

Diodontus filicornis sp. nov.

Readily separated from its allies by the cylindrical joints of the flagellum.

Male.—Length, 7.5 millimeters. Anterior margin of clypeus with two small teeth medianly; transverse carina below antennæ strong and joining the equally strong frontal carina; eyes converging toward clypeus; frons and vertex shining; ocelli in a low triangle, the anterior ocellus in a shallow depression; postocellar line subequal with ocellocular line; antennæ as long as head and thorax, the joints cylindrical, not produced beneath, third joint somewhat longer than fourth; anterior margin of pronotum carinate, lateral anterior angles rounded; scutum polished, but with a few distinct punctures; notauli wanting; suture in front of scutellum finely foveolate; dorsal surface of propodeum polished, basal area rectangular in outline and with strong rugæ; median channel of propodeum deep; posterior face of propodeum coarsely reticulate; mesepisternum polished, the suture not foveolate; petiole gently curved, cylindrical, subequal with hind femur, well separated from rest of tergite; first recurrent received by first cubital a short distance before apex; second recurrent gently bisinuate, received by third cubital cell a distance somewhat greater than half the length of second intercubitus from its base; second cubital about one-third longer below. Head and thorax black; mandibles (except apices) and scape yellow; flagellum brown, testaceous at base beneath; dorsal part of pronotum, scutum except three black elongate spots, scutellum, metanotum, posterior face of propodeum (except median furrow), two spots below anterior wing and one below posterior wing yellow; base of petiole yellowish, apex black; gaster rufous; four anterior legs and posterior coxæ yellowish;

hind legs beyond coxæ testaceous; head with the usual silvery pubescence; wings hyaline, venation pale brown.

Type locality.—Basilan Island.

Described from one male received from C. F. Baker under his number 16826.

Type.—Catalogue No. 25043, United States National Museum.

Diodontus davanus sp. nov.

Very like *Diodontus luzonensis* Rohwer, but that species lacks the transverse ridge below the antennæ.

Male.—Length, 7 millimeters. Anterior margin of clypeus produced medianly into a low, rather narrow, emarginate process; transverse ridge below antennæ strong, gently curved laterally and medianly joining the equally prominent frontal ridge; inner margins of eyes converging toward clypeus but closer together opposite insertion of antennæ; frons and vertex shining; ocelli in a low triangle; postocellar line subequal with ocellocular line; antennæ nearly as long as head and thorax, joints 7 to 12 rounded out beneath, joints 3 and 4 subequal; pronotum strongly carinate anteriorly, lateral anterior angles rounded; scutum shining, with a few well-separated punctures; notauli present on about anterior half; suture in front of scutellum foveolate; dorsal surface of propodeum polished, the basal area triangular in outline and with strong rugæ which are well separated medianly; median channel deep and well defined; posterior face of propodeum coarsely reticulate; mesepisternum polished, the suture not foveolate; petiole evenly curved, cylindrical, subequal in length with hind femur and well separated from rest of tergite; gaster polished; first recurrent received in second cubital very close to first intercubitus; second recurrent bisinuate, received in third cubital cell a distance slightly less than half the length of second intercubitus from base of cell; second cubital cell one-third longer below. Head black, mandibles and scape yellow; flagellum brownish above, testaceous beneath; thorax yellow; anterior part of pronotum, spot below tegula, posterior part of mesepisternum, metapleura, three spots on scutum, narrow line before scutellum, and base of propodeum as well as propodeal furrow black; base of petiole yellowish, its apex brownish; gaster rufous; legs rufous-testaceous; head with usual silvery hair; wings hyaline, venation brown.

Type locality.—Davao, Mindanao.

Described from one male received from C. F. Baker.

Type.—Catalogue No. 25044, United States National Museum.

Diodontus ajaxellus sp. nov.

Apparently somewhat like *Psen ornatus* Ritsema but differs in some color markings and in venation.

Male.—Length, 7 millimeters. Slender. Anterior margin of clypeus with two small, triangularly shaped teeth medianly; transverse ridge below antennæ strong, and joining the equally strong frontal ridge medianly; frons and vertex shining; ocelli in nearly an equilateral triangle; postocellar line slightly less than ocellocular line; antennæ as long as head and thorax, joints 6 to 12 rounded out beneath, third joint subequal with fourth; pronotum carinate anteriorly, lateral anterior angles sharp but not dentate; scutum polished and with a few punctures; notauli indicated anteriorly; dorsal surface of propodeum polished, basal area triangular in outline and crossed by strong rugæ which are more widely separated medianly; posterior face of propodeum coarsely reticulate, the median channel deep; mesepisternum polished, the suture foveolate; petiole gently curved, cylindrical, fully as long as hind femur, not very sharply separated from rest of tergite; gaster polished; first recurrent received by first cubital cell close to first intercubitus; second recurrent bisinuate, received by third cubital a distance equal to half the length of second intercubitus from base of cell; second intercubitus perpendicular; second cubital cell one-third longer below. Head and thorax black; mandibles and scape yellow; flagellum, from the basal joints, testaceous beneath; dorsal part of pronotum, three spots on mesepisternum (the lower one smallest), spot below hind wings, scutum except three broad lines, scutellum, metanotum, and posterior face of propodeum (except median channel) yellow; four anterior legs and hind coxæ yellow; hind legs below coxæ testaceous; abdomen rufous, base of petiole yellowish; head with the usual pale pubescence; wings hyaline, venation pale brown.

Type locality.—Kolambugan, Mindanao.

Described from one male received from C. F. Baker.

Type.—Catalogue No. 25045, United States National Museum.

Diodontus esuchus sp. nov.

Male.—Length, 8 millimeters. Close to *Diodontus ajaxellus* sp. nov., from which it differs as follows: More robust; third antennal joint distinctly longer than fourth; petiole strongly curved; first recurrent received by first cubital a distance equal to about one-third the length of first intercubitus from end of cell; second cubital cell about one-fourth longer below (due to

the nearly perpendicular first intercubitus); four anterior femora brownish beneath; hind legs brownish with tarsi black; apex of petiole black.

Type locality.—Sandakan, Borneo.

Described from one male received from C. F. Baker under his number 16828.

Type.—Catalogue No. 25046, United States National Museum.

Diodontus xanthognathus Rohwer.

The following specimens submitted by C. F. Baker have been examined: Female, from Singapore, Straits Settlements (*Baker 16830*); female, from Penang Island; male, from Sandakan, Borneo (*Baker 16827*); male, from Tangcolan, Bukidnon, Mindanao.

Psen (Mimesa) bakeri sp. nov.

Very like *Psen* (*Mimesa*) *politiventris* Rohwer, but it differs as follows and can hardly be the male of that species:

Male.—Length, 10.5 millimeters. Produced part of clypeus without a median emargination; pubescence of face silvery; petiole bicarinate laterally; scutum rather closely striate-punctate; scutellum more coarsely punctured and with a tendency to striate puncturation; propodeal inclosure flat, shining, without a median channel but with ten rugæ; second recurrent a short distance beyond second intercubitus; wings hyaline. Antennæ longer than head and thorax, third joint distinctly longer than fourth, flagellar joints 6 to 9 slightly constricted at base and apex beneath.

Type locality.—Haight's Place (Pauai), in mountains near Baguio, Mountain Province, Luzon. Altitude about 2,500 meters.

Described from one male (*Baker 16825*).

Type.—Catalogue No. 25047, United States National Museum.

A DISEASE OF SATSUMA AND MANDARIN ORANGE FRUITS CAUSED BY GLOEOSPORIUM FOLIICOLUM NISHIDA

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ONE PLATE AND ONE TEXT FIGURE

OCCURRENCE AND DISTRIBUTION

The Unshiu oranges, *Citrus nobilis* var. *unshiu,* are loose-skinned fruits closely related to the mandarin oranges and are the most commonly grown citrus fruits in Japan. Until recently the Unshiu oranges were not grown commonly elsewhere than in Japan, but in the last twenty years these varieties have been grown in the Gulf States of the United States rather extensively although they are known there as Satsuma oranges. According to Tanaka(10) there are six strains, or perhaps they may be called varieties, of the Unshiu oranges; Owari, Zairai, Ikiriki, Ikeda, Hira, and Wase.

In September, 1919, a disease was observed upon fruits of the Wase Unshiu orange, at Saigo, Nagasaki Prefecture, Japan. In the orchard where it was first observed only two trees showed the disease, the fruits of those two trees, however, showing at least 20 per cent of the fruits affected. At Saigo, this was the first season that the disease had been observed. The disease was next observed in the Arita River Valley, Wakayama Prefecture. Two trees only of the Wase Unshiu variety were observed, but one fruit upon one of these trees showed a typical case of the Wase rot. The owner of the trees stated that he had observed this trouble the previous year, but that this year it was not so serious. He had not seen the disease before that time. At Tsukumi, Oita Prefecture, the disease was again observed. The Wase Unshiu variety is being planted rather extensively in this place, and the disease was correspondingly prevalent. One orchard was seen in which the fruits were entirely unharvested as yet. In this orchard the number of affected fruits was conservatively 10 per cent of the total crop.

The Wase Unshiu variety is also planted commercially at Ocho, Hiroshima Ken. The disease was observed at this place also, although at the time of the observation most of the fruits were harvested and no estimate of the injury due to the disease could be made. The disease was said to have been first seen two years before and at that time was very serious; during the present year (1919) it was not so injurious.

DESCRIPTION OF THE DISEASE

The disease has so far been observed only upon the Wase Unshiu variety in the field; it has not yet been observed occurring naturally upon any of the other varieties of the Unshiu oranges or upon any of the other *Citrus* species. The disease is very peculiar in this respect in that in nature in Japan it seems to be limited to a single horticultural variety, while closely related varieties are not at all affected.

The disease has so far been observed affecting only the fruits. The skin of the fruit becomes a brown color; the spot spreads quickly, the center of the spot becoming lighter and grayish in color, while the advancing edges of the spot remain dark brown or even become dead black. The spot is slightly depressed and a very definite line of demarcation exists between the diseased spot and the normal skin. The size and the shape of the spots vary; a spot may be as small as 2 to 3 millimeters in extent in its longest diameter while the largest spot observed was 50 millimeters in its longest diameter. The longest diameter is typically in a lateral direction as shown in Plate 1. As the disease advances small black pustules can be seen forming in large numbers in the grayish center of the lesion; these are the acervuli of the causal fungus and contain the spores of the fungus in large numbers. The spots appear typically near the blossom end of the fruit, usually just to one side of the navel, never at the navel. The spots have never been observed as yet to occur near the stem end of the fruit.

The injury to the fruits is at first confined largely to the skin and does not extend into the flesh of the fruit. In the early stages of the disease, therefore, although the skin may be blackened, giving to the fruit the appearance of being badly rotted, it will nevertheless be intact within and perfectly edible. With the advance of the disease, other fungi intrude which spread into the flesh of the fruit more readily, and the fruit becomes spoiled for use and quickly rots. The fruits, moreover, when once affected, quickly drop to the ground and there

rotting of the fallen fruits proceeds more rapidly. As a general thing fruits affected with this disease are a total loss to the grower. The colored photograph, Plate 1, probably gives a better idea of the disease than does the written description. This disease has been called in the field Wase Unshiu rot, because the disease in nature has been confined to the Wase Unshiu variety and the word rot is fairly descriptive of the trouble. Probably, for the use of pathologists, the term anthracnose of Unshiu oranges would be more descriptive.

THE CAUSE OF THE DISEASE

Attempts at isolation of a causal fungus were first made with fruits obtained at Saigo. The isolation attempts resulted uniformly, a fungus of the genus *Gloeosporium* being obtained in every planting in each plate. This fungus was maintained in pure culture and inoculated into perfectly healthy fruits of the Wase Unshiu orange. The inoculation data and results are given in Table 1.

TABLE 1.—*Showing results of inoculation experiments to reproduce Wase rot on ripe Wase Unshiu orange fruits. Inoculations made with needle punctures in fruits in moist chambers at laboratory temperatures, 26 to 30° C., on October 2, 1919; results observed October 21, 1919.*

No. of inoculated fruit.	Inoculum.	Result.	No. of inoculated fruit.	Inoculum.	Result.
1	Tap water	Negative.	19	Infusion of *Gloeosporium* species.	Positive.
2	do	Do.			
3	do	Do.			
4	do	Do.			
5	do	Do.	20	do	Negative.
6	do	Do.	21	do	Do.
7	do	Do.	22	do	Positive.
8	do	Do.	23	do	Do.
9	do	Do.	24	do	Do.
10	do	Do.	25	do	Do.
11	do	Do.	26	do	Do.
12	do	Do.	27	do	Do.
13	Infusion of *Gloeosporium* species.	Do.	28	do	Do.
			29	do	Negative.
			30	do	Positive.
			31	do	Do.
14	do	Do.	32	do	Do.
15	do	Do.	33	do	Do.
16	do	Do.	34	do	Negative.
17	do	Do.	35	do	Do.
18	do	Do.	36	do	Do.

Table 1 shows the control inoculations to have remained entirely healthy, while the inoculations with the fungus infusion produced twelve cases of the disease from a total of twenty-four attempts. That is, 50 per cent of the inoculations with the fungus resulted in positive cases of the disease.

The inoculations were then repeated upon fruits still remaining on the tree under orchard conditions. Of thirty such inoculation attempts made under orchard conditions with the *Gloeosporium* fungus, ten positive cases of the disease resulted. The inoculations in this case were made with needle punctures, the only difference between this series of inoculations and those reported in the preceding table being that the inoculations in the orchard were made at normal air humidity while those reported in the table were made at an artificially maintained, high humidity. Control inoculations made with tap water and needle punctures again yielded entirely negative results. The *Gloeosporium* fungus was again reisolated from the inoculations resulting positively, and upon reinoculation upon Wase fruits again produced the disease. Inoculations have since been made repeatedly with positive results in reasonable percentages of cases. The postulates of Koch have thus been fulfilled, and the inoculation experiments lead to the statement that the disease of Wase Unshiu orange fruits is caused by this fungus of the genus *Gloeosporium*. The fungus was subsequently isolated from affected fruits obtained at Tsukumi. To the present time three different series of inoculations with this *Gloeosporium*, without punctures, have failed to reproduce the disease, indicating that the fungus is dependent upon wounds or bruises for entrance.

IDENTIFICATION OF THE FUNGUS

The fruiting bodies of the fungus occurring both naturally on diseased fruits and in culture are the typical *Gloeosporium* acervuli. The masses of spores resulting on the fruits are most often black en masse, but in fresh cultures are usually pink. The individual conidiophores are often branching as shown in figure 1 and are characteristically tapering at the tip. The spores when newly formed are elongate, slightly tapering to the ends, and the ends are usually rounded. In old cultures the spores may assume a number of eccentric shapes. When newly formed the spores are hyaline and few or no granular bodies are to be seen. Spores from old cultures, however, become something of an olive shade and are very granular; one or two vacuoles are

frequently to be seen in old spores. The size of the spores is from 4.3 to 6.0 by 15.0 to 21.5 μ. Morphologically, therefore, the fungus agrees entirely with *Gloeosporium foliicolum* Nishida. The fungus has been grown in culture side by side with a known culture of *Gloeosporium foliicolum* obtained from herbarium material of that fungus forwarded by Doctor Nishida. Upon nutrient agar slants, potato plugs, poured plates, and orange-wood plugs, no cultural differences are discernible. The Wase rot fungus fruits several days more slowly than does the known culture of *Gloeosporium foliicolum,* but such a difference cannot be considered as an essential distinction.

A culture of Doctor Nishida's *Gloeosporium foliicolum* was then used as the inoculum for tests on Wase fruits. These inoculations yielded positive results in about 33 per cent of the tests, the lesions corresponding entirely with the Wase spot disease as it occurs in the field. These inoculation results, together with the morphological and cultural similarity, would indicate that the fungus causing the Wase rot is identical with *Gloeosporium foliicolum* Nishida.

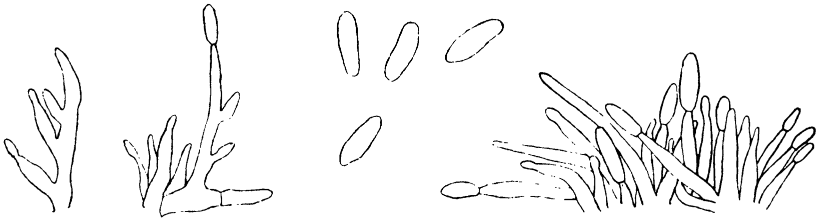

FIG. 1. *Gloeosporium foliicolum* Nishida, showing spores and conidiophores, × 500.

THE RELATIONSHIPS OF GLOEOSPORIUM FOLIICOLUM, G. LIMETTICOLUM, AND COLLETOTRICHUM GLOEOSPORIOIDES

Anthracnose and wither tip of limes, lemons, oranges, and pummelos ascribed to *Colletotrichum gloeosporioides* were reviewed and described from Florida by Rolfs.(8) He described this fungus as attacking small, newly formed lime fruits, newly formed lime twigs, mature lemons, newly formed twigs of lemon, and newly formed twigs of orange and grapefruit, but not the fruits of orange and grapefruit. Clausen (1) later has shown that wither tip of the lime and lemon was not due to *Colletotrichum gloeosporioides,* but to a species that is quite distinct in morphological and cultural characters and in physiological activities; he described this species as *Gloeosporium limetticolum.* Clausen did not have the opportunity to inoculate young lime fruits, although he states the opinion that the anthracnose of young lime

fruits is probably due to *G. limetticolum*. Although the serious wither tip and anthracnose of the lime and lemon are due to *G. limetticolum*, *Colletotrichum gloeosporioides* is regarded by Fawcett(5) as the cause of rots of mature fruits of citrus varieties. Darnell-Smith and Mackinnon(3) in New South Wales have also described a disease, brown spot of Emperor mandarin orange fruits, which they ascribe to *C. gloeosporioides*. There are, therefore, two fungus species apparently pathogenic upon *Citrus* species, neither of which has been considered by Nishida in describing his new *Gloeosporium* species.

Nishida's(7) description of this species is in Japanese, and since it is probably inaccessible to most American and European pathologists, a translation is presented here:[1]

There are differences between this disease and *Gloeosporium citricolum* Massee in the respect that the former has septa in its conidiophores and its conidiophore branches. So these two fungi are clearly different. Since to my knowledge no fungus has been previously described similar to this, parasitic on citrus trees, I recognize it as a new species and name it *Gloeosporium foliicolum* sp. nov.

Its characters are as follows: The groups of spores grow often below the cuticle on the upper sides of the leaves. Later the cuticle of the leaf splits and the groups of spores upheave. The spores scatter or sometimes ooze. The color of the spore group is light reddish brown and its diameter is about 120 micro-millimeters. It also grows on the surface of the dead, newly grown twig and fruits. The conidiophores grow densely in bundles; the shape of each conidiophore is cylindrical and its tip is slightly pointed; it is frequently branched. It has two or three septa and is colorless; its length is 36–48 μ and its width is 4–5 μ. The spore grows on the tip of the conidiophore and has no curve; the tip of the spore is round and is slightly sharp (narrowing or pointed); there are few granular things in its body and it is colorless; it is twenty to fourteen μ in length and 4–6 μ in width. It germinates from one end.

This fungus parasitizes all citrus trees but gives specially much damage on navel orange, unshiu orange, and natsu daidai.

In conversation with Doctor Nishida it developed that in describing this fungus as the cause of a leaf-fall disease of *Citrus*, the organism had not been isolated in culture nor had subsequent inoculations been made. It has seemed desirable, therefore, to compare this fungus with the closely related pathogenic species on *Citrus*, *Colletotrichum gloeosporioides* and *Gloeosporium limetticolum*.

The following cross-inoculation data and comparisons are therefore submitted, not as entire proof of the validity of

[1] The translation of this passage from Nishida's book on citrus diseases is through the kindness of Mr. T. Takahashi, formerly plant inspector, Nagasaki Plant Quarantine Station.

G. foliicolum but as work that may be of assistance to a later investigator.

The Japanese fungus on mandarin and Unshiu oranges.—The Japanese disease in the field has been confined entirely to fruits of the Wase Unshiu variety and no cases were observed upon other species such as the sweet orange, *Citrus sinensis;* the lemon, *Citrus limonia;* the pummelo, *Citrus maxima;* or the sour orange, *Citrus aurantium.* Trees of the five other recognized varieties of the Unshiu orange commercially grown in Japan in many cases were observed in the same orchards, side by side with trees of the Wase variety; nevertheless, none of the Wase rot was ever observed upon such other varieties. The Wase Unshiu variety is an early-bearing variety; in fact, a translation of the Japanese word Wase is early. Fruits of the Wase variety mature during the summer heat of early September, while the other varieties mature in late October, November, or even December when the temperature is 30 to 40° F. lower.

Inoculations made in the field upon immature fruits of the Zairai, Ikeda, and Ikiriki varieties resulted entirely negatively in early October, while identical inoculations upon the Wase variety resulted positively. Later inoculations were made upon mature Zairai fruits removed from the trees and held in an incubator at 26 to 28° C. These resulted positively in two out of ten cases in the first test and in one out of ten cases in the second series. Inoculations upon fruits of the Ikiriki Unshiu orange under the same conditions resulted in one positive case from a total of ten fruits, and in the second series in seven cases from a total of ten fruits. It seems reasonable to conclude from this, therefore, that the lower temperatures at the time of maturing of the Ikiriki and Zairai Unshiu varieties limit the disease on these varieties, and that the occurrence of the disease in the field on the Wase variety alone is not a host restriction but a temperature limitation.

A series of inoculations upon Wase Unshiu fruits as compared with inoculations upon Batangas (Philippine) mandarin oranges, resulted in 65 per cent positive cases from twenty Wase Unshiu orange fruits and 55 per cent positive cases from twenty Batangas mandarin orange fruits. The Batangas mandarin orange, a form of *C. nobilis* var. *deliciosa,* was therefore readily susceptible to this disease; apparently then the Japanese fungus is capable of infecting mature fruits of either the Unshiu or the mandarin oranges if temperature conditions are favorable.

Inoculations upon mature lemon, sweet orange, and pummelo fruits.—Inoculations in the incubator at 25 to 26° C. were then made upon mature fruits of American-grown lemons, *C. limonia,* and Japanese-grown Washington navel oranges, *C. sinensis,* and pummelos, *C. maxima.* Upon the pummelos (Hirado variety) two different series of ten fruits each were tried; all resulted negatively. The Washington navel fruits in two series of twelve fruits each all resulted negatively. The American lemons in a single series of twelve fruits also resulted entirely negatively. Control inoculations on twelve Ikiriki Unshiu fruits resulted in 58 per cent positive cases. These data can best be seen in tabular form as follows:

TABLE 2.—*Showing results of inoculations with infusion of spores of Gloeosporium foliicolum on fruits in incubator at 25 to 26° C., each fruit inoculated with one needle puncture.*

Variety.	Fruits inoculated.	Date of inoculation.	Positive results.	Date of results.
		1919	*P. ct.*	1919
Zairai Unshiu orange	10	October 30	20	November 20.
Do	10	November 5	10	December 7.
Ikiriki Unshiu orange	10	November 5	10	December 7.
Do	10	October 14	70	December 6.
Hirado Buntan (pummelo)	10	November 5	0	December 7.
Do	10	October 30	0	November 20.
Washington navel orange	20	October 14	0	November 10.
Do	12	October 23	0	November 20.
American lemons	12	October 23	0	November 20.
Ikiriki Unshiu orange	12	October 23	58	November 20.

From these results it would seem that the fungus is restricted to the fruits of *Citrus nobilis,* and has no pathogenicity on fruits of other species.

The results from the foregoing series of inoculations in the incubator were repeated under orchard conditions, using both fruits and twigs. Since Clausen's opinion is that anthracnose of young lime fruits is due to *Gloeosporium limetticolum,* emphasis was placed upon the inoculation of such young fruits since the results would show definitely the similarity or differences between the Japanese fungus and *G. limetticolum.* The results are shown in Table 3.

These inoculations show clearly the pathogenicity of the Japanese *Gloeosporium* on mandarin oranges and the entire absence of pathogenicity on young lime fruits or mature limes, lemons, or sweet oranges. Further inoculations were made on fifteen

young, actively growing Tahiti lime twigs; twenty young, actively growing leaves of Unshiu orange trees; thirty old senile leaves of the same species; and twelve twigs of a mandarin orange tree. The results of the last inoculations were entirely negative in each case, while controls on Batangas mandarin orange fruits were positive.

TABLE 3.—*Showing results of inoculations with control punctures and punctures with infusion of spores of Gloeosporium foliicolum on fruits under orchard conditions.*

Variety.	Condition.	Fruits inoculated.	Inoculum.	Incubation period.	Positive results.
				Days.	*Per cent.*
Batangas mandarin oranges	Mature	20	Water	15	0
West Indian limes	do	20	do	15	0
American lemons	do	20	*G. foliicolum*	15	[a]0
Sweet oranges	do	20	do	15	0
Batangas mandarin oranges	do	20	do	13	55
West Indian limes	do	40	do	15	0
American lemons	do	20	do	15	[a]0
Sweet oranges	do	20	do	15	[a]0
Tahiti limes	Newly formed	8	do	15	0

[a] Slight gumming at few of the inoculations but could scarcely be called positive.

The inoculations were repeated with similar results; all the inoculations on twigs remained negative, while on mandarin orange fruits positive results were obtained. Apparently, if, as described by Nishida, this fungus causes a wither tip disease of young, actively growing twigs, a peculiar set of environmental conditions is necessary or a weakened host plant is essential. In the cases of *Colletotrichum gloeosporioides* Penzig, such is the case according to R. E. Smith and E. H. Smith,(9) E. O. Essig,(4) and R. E. Clausen.(1)

The results would seem to warrant the retention for the present at least of Nishida's species, *Gloeosporium foliicolum,* since it is particularly pathogenic to mature fruits of the Unshiu and mandarin oranges, *Citrus nobilis;* while of the closely related species it is distinguished from *Colletotrichum gloeosporioides* by its absence of pathogenicity on mature fruits of lemon and sweet orange, *C. limonia* and *C. sinensis,* and from *Gloeosporium limetticolum* by being nonpathogenic to young fruit and twig tissues of the lime, *C. aurantifolia.*

The pressure of other work prevents a more complete study of these three fungi, morphologically and in culture as well as physiologically.

Since writing the foregoing account I have been able to obtain an English translation of the Japanese article "On the pathogenic nature of Nishida's anthracnose fungus of citrus," by Dr. Takeo Hemmi.(6)

Hemmi, working with potted plants, carried on five experiments, using an inoculum of *Gloeosporium* spores in sterile water obtained from cultures from herbarium material of Nishida's fallen-leaf disease. In the first experiment, this inoculum placed on the leaves of Unshiu orange, navel orange, bitter orange, and pummelo resulted negatively in all cases. There is no mention of bell jars or moisture chambers in this experiment and apparently the inoculations were carried on in the open air.

In the second experiment, using the same inoculum, leaves of a potted plant of the Unshiu orange were inoculated; leaves of a potted plant of the sour orange (*Citrus aurantium* presumably) were similarly inoculated and both plants placed under bell jars and extremely moist conditions obtained with damp filter paper. Two days after the inoculation the bell jars were removed. The sour orange tree remained negative during twelve days after inoculation, but three leaves on the Unshiu orange tree turned brown, the leaves dropped and *Gloeosporium* acervuli appeared in a few days.

The third experiment consisted of the inoculation of the same material onto leaves of potted plants of the Unshiu orange and navel orange; bell jars and moist filter paper were maintained around the plants for three days after the inoculation and the plants were then restored to the normal air of the room. After twelve and thirteen days, spreading brown spots appeared on the leaves of the Unshiu orange and the leaves soon fell to the ground. *Gloeosporium* acervuli formed on the fallen leaves. Uninoculated leaves on the same plant remained healthy and did not fall from the tree. In none of the inoculations were artificial punctures or other injuries given to the leaves. No changes whatsoever occurred on the inoculated leaves of the navel orange.

In the fourth experiment, with similar methods, inoculations were made on leaves of a sour orange tree and on leaves of a pummelo. All leaves remained negative with the exception of one leaf of the sour orange which formed the typical spreading brown spot and fell to the ground. Doctor Hemmi was of the opinion that this positive result occurred at a naturally occurring wound.

In the fifth experiment, with similar methods, leaves of Unshiu orange, sour orange, and pummelo were inoculated. The young leaves of the Unshiu orange showed positive results and fell to the ground; on placing in a moist chamber they developed *Gloeosporium* acervuli. The leaves of the sour orange and pummelo remained negative as did also uninoculated leaves of the Unshiu orange.

These experiments, although apparently on a small scale, would indicate that under unusual weather conditions *Gloeosporium foliicolum* can attack normal leaves of the Unshiu orange, but that the fungus is but slightly pathogenic, if at all, to other *Citrus* species. The conclusions are also in agreement with those of the present paper pointing to the host restrictions of this fungus to *Citrus nobilis* and the validity of Nishida's *Gloeosporium foliicolum.*

Hemmi in his conclusions is apparently of much the same opinion in regard to the pathogenicity of this fungus on foliage as are investigators in California in regard to the pathogenicity of *Colletotrichum gloeosporioides;* that is, that unusual climatic conditions must be favorable to the fungus for it to become pathogenic to the foliage. In fruit inoculations we have found that such unusual conditions do favor pathogenicity but are not essential.

DISCUSSION

The Japanese disease on Unshiu oranges is quite possibly identical with the disease of emperor mandarin oranges described from Australia. Although the lesions on Unshiu oranges are slightly larger than are the lesions shown in the photographs by Darnell-Smith and Mackinnon(3) on mandarin oranges in Australia, such a slight difference could easily be explained by differences in host reactions. The cross inoculation experiments reported here cannot be considered as more than preliminary, yet they warrant the consideration of Nishida's *Gloeosporium foliicolum* as distinct from *Gloeosporium limetticolum* Clausen and *Colletotrichum gloeosporioides* Penzig. For the purposes of plant quarantine work also it seems justifiable to regard the disease of mandarin and Unshiu oranges as distinct from other kinds of anthracnose and wither tip on *Citrus* hosts. Anthracnose of mandarin oranges does not yet exist in the Philippines, nor has it been reported from America. It is especially important to the Philippines, where mandarin oranges are the principal commercial citrus crop, that this disease be excluded.

SUMMARY

1. A disease exists in Japan upon the Wase Unshiu orange variety, which has been observed to cause a loss of 20 per cent of the crop and is capable of causing even greater losses. Although the disease is confined to this one variety in nature in Japan, inoculation experiments have shown that at higher temperatures the disease will affect other varieties of the Unshiu oranges and also mandarin oranges.

2. The disease is described and isolation and inoculation experiments are reviewed showing the disease to be caused by a fungus identical with *Gloeosporium foliicolum* Nishida.

3. Inoculation experiments with this fungus on different *Citrus* species are also reviewed, indicating in a preliminary way that *Gloeosporium foliicolum* is a valid species and distinct physiologically from *Gloeosporium limetticolum* and *Colletotrichum gloeosporioides*. It is pointed out that, in the light of inoculation experiments, countries where this disease is not yet reported are justified in preventing the introduction of this fungus.

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ILLUSTRATIONS

PLATE 1. Anthracnose of Wase Unshiu oranges in Japan caused by the fungus *Gloeosporium foliicolum* Nishida.

TEXT FIGURE

FIG. 1. *Gloeosporium foliicolum* Nishida, showing spores and conidiophores, × 500.

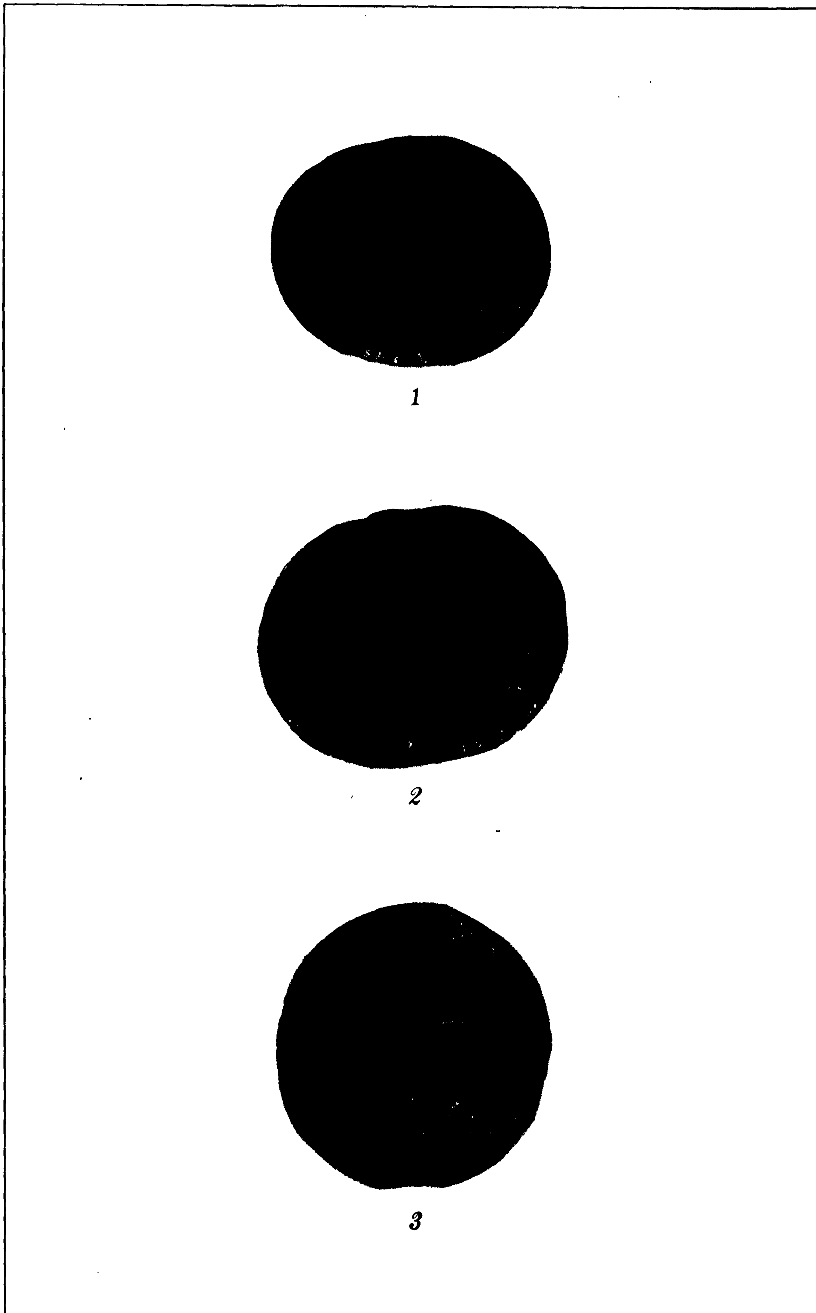

PLATE 1. ANTHRACNOSE OF WASE UNSHIU ORANGES IN JAPAN CAUSED BY THE FUNGUS GLOEOSPORIUM FOLIICOLUM NISHIDA.

THE SOLID BITUMENS OF LEYTE

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TWO PLATES AND TWO TEXT FIGURES

Natural solid bitumens occur in Leyte Province in two forms: pure bitumens and bitumen-impregnated rocks. The outcrops of pure bitumen occur in thin veins, while bitumen-impregnated rocks are found disposed in strata and in faults. Maps drawn by Pratt, who does not distinguish between the two varieties of bitumens, show the location of bitumen throughout the island.[1] One of these maps is reproduced here as text figure 1.

The pure bitumens of Leyte possess but little interest from the point of view of industrial development. Their applications might be numerous if large quantities of the material existed, but it has been found in very limited amounts. However, the rock presents a certain scientific interest, as it differs from all known mineralogical species of pure bitumen, and the study of its composition is also interesting in view of its relationship to the second variety of bitumens. The latter presents considerable economic importance as it occurs in large quantities and has been found practicable for road building.

In view of this, I will give only a cursory description of the pure bitumen and will consider the bituminous rocks in somewhat greater detail.

PURE BITUMEN

The samples of this material which I studied have been taken from outcrops that were disposed horizontally at the foot of a hill, within a layer of shale, covered by a layer of clay, about 2 to 3 kilometers southeast of Campocpoc, west of Bagubao River, in the northwestern part of the island. They had the appearance of dark brown stones of considerable hardness and brittleness and conchoidal fracture, yet they were not sufficiently brittle to be pulverizable. Their surface, lustrous when fresh, presented greasy spots when aged, betraying the lack of perfect homogeneity. Rubbed against unglazed porcelain the rock leaves a brownish yellow streak.

[1] Philip. Journ. Sci. § A 10 (1915) 241.

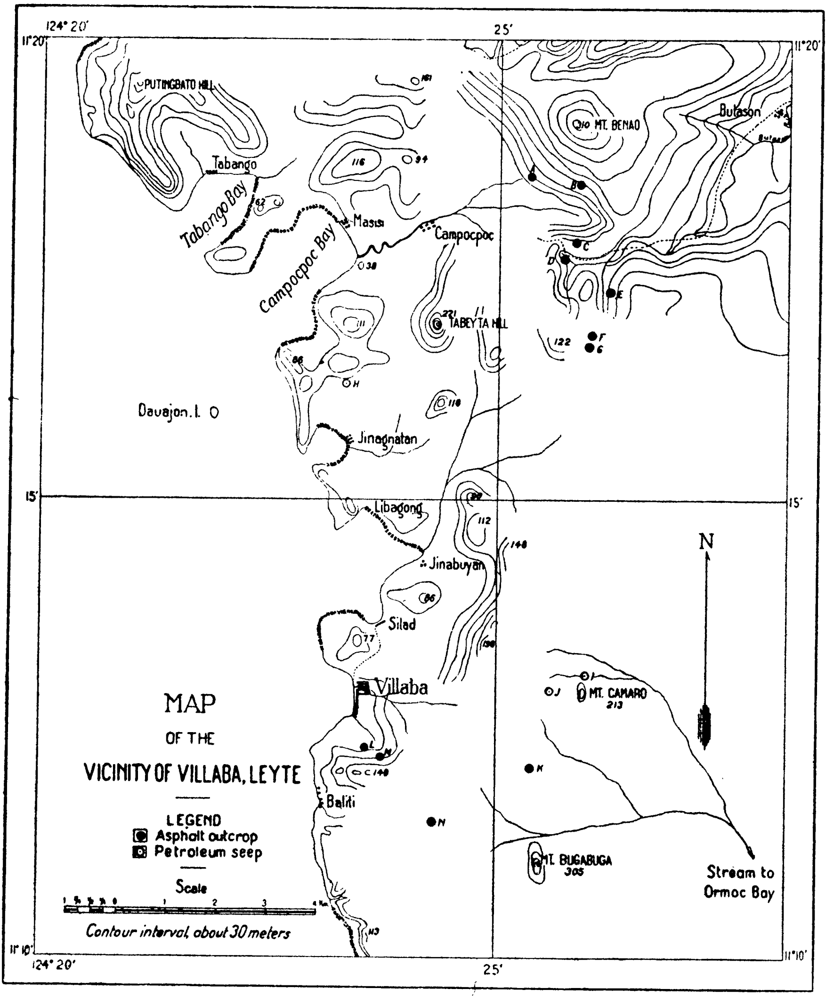

FIG. 1. The vicinity of Villaba, Leyte, showing the situations of outcrops of natural bitumens and seepages of petroleum.

Constants of pure bitumen of Leyte.

Physical constants:	
Melting point (capillary) (° C.)	61.5
Specific gravity at 25° C. (77° F.)	0.978
Ductility	0
Penetration (degrees)	2
Chemical constants:	Per cent.
Ethyl acetate soluble (paraffins)	81.5 –90.5
Ethyl acetate insoluble (asphalt)	7.9 –14.5
Mineral matter	0.5 – 2.8
Volatile matter at 265° C.	1.15
Fixed carbon	8.76– 9.99

On distilling, the rock commences to emit gases at temperatures above 300° C.; these gases are only partly condensable and are due to the breaking up and decomposition of paraffin hydrocarbons of high molecular weight into hydrocarbons of lower series. Distilled hydrocarbons represent about 70 per cent of the total weight of the rock; noncondensable gases, about 3 per cent; and the residue consists of the remaining 27 per cent which has become carbonized. The distillate, which is a mixture of solid and liquid hydrocarbons, constitutes a vaselinelike or butterlike grease, leaving a greasy spot on paper. It acts as a perfect mineral lubricant. Alcohol dissolves only the liquid oil, leaving the solid hydrocarbons behind as a yellow wax.

The ethyl acetate insoluble (asphalt) portion of the bitumens is always hard; it dissolves in benzene and, on evaporation of the solvents, deposits at the bottom of the vessel a brilliant black lacquer which scarcely adheres to the vessel. On heating, it does not melt, but softens at high temperatures.

The ethyl acetate soluble (paraffins) extracted from the bitumens presents a hard waxy substance, dark brown when seen in large masses, but reddish yellow when observed in thin layers. Solutions in all solvents present a very marked fluorescence. The ethyl acetate soluble being a mineral wax, it is very important to ascertain whether it consists of ceresin or of paraffin hydrocarbons. Its melting point, 60 to 61° C., is at the limit of that of paraffins and ceresin hydrocarbons, but its extraordinary capacity for crystallization and some of its physical properties, particularly its brittleness, indicate that it consists mostly of paraffin.

Leyte pure bitumens are essentially mineral waxes and must be classified as such, in spite of the admixture of 10 per cent (on the average) of ethyl acetate insoluble asphaltenic elements. The only varieties of natural mineral waxes hitherto known were those slightly metamorphosed residues of paraffinaceous petroleum which contain practically no asphaltenic ingredients, such as ozocerite, montan wax, hatchettite, and scheererite. It would be quite impossible to classify this rock as montan wax, hatchettite, or scheererite; the following circumstances make it difficult to classify it as ozocerite either. Ozocerite is subjected industrially to a process of refining which consists in heating it with about 20 per cent by weight of concentrated sulphuric acid to 280 to 300° C. until the evolution of sulphur dioxide fumes ceases. Concentrated sulphuric acid attacks and destroys unsaturated hydrocarbons and resinous matter, while volatile hydrocarbons

are eliminated in the process of heating; there remains ceresin, which is a mixture of saturated hydrocarbons of high molecular weight. Ceresin is a species of mineral paraffin wax, but it is distinguished from the substance ordinarily designated paraffin by having a higher molecular weight, a higher melting point, a higher specific gravity, and a higher index of refraction, and by being flexible, noncrystallizable, and less soluble in organic solvents. Ozocerite is mined only for the purpose of obtaining ceresin. This being the case, a mineral which is not composed of ceresin should not be called ozocerite. No ceresin can be obtained from Leyte bitumens by a process of refining similar to that used for refining ozocerite. The paraffin extracted from Leyte bitumens is a hard and nonplastic substance with a penetration at 77° F. of 4° while ceresin is a plastic mass whose penetration at the same temperature is 20 to 30°. Finally, ozocerite is, as its name indicates, an odorous wax; the Leyte rocks have no odor at ordinary temperatures.

A natural mineral wax has been mined for the last thirty years in Colorado which has received no name as a mineralogical species and is commonly referred to as "ozokerite-like wax" or "so-called ozokerite of Colorado." Judging by the descriptions [2] the Colorado rock has certain points of resemblance to the Leyte pure bitumen. Like the latter, it does not yield ceresin, this being the reason why it is not classified as an ozocerite, and it produces paraffin wax on being distilled at temperatures above 360° C. From the descriptive literature, however, it is evident that it represents a species different from our Leyte bitumen since, unlike the latter, it does not contain a considerable quantity of asphaltenic ingredient insoluble in light petroleum naphtha and in boiling ethyl acetate. The Colorado bitumen, moreover, is pulverizable, smells of catechu, melts at 76° C., and yields 90 per cent of paraffin and oil on distillation.

Thus we see that our Leyte rocks cannot be classified as any of the known varieties of bitumen and should be given a special name: Leyteite, as it can be called, belongs to the group of mineral waxes and is related to ozocerite more than to any other mineral.

BITUMEN-IMPREGNATED ROCK

The samples of this material that I analyzed were obtained from the Lucio mine, the property of the Leyte Asphalt and Min-

[2] Lach, Chem. Ztg. 13 (1889) 831; Journ. Soc. Chem. Ind. 8 (1889) 696.

eral Oil Company. According to Dr. Roy E. Dickerson,[3] who kindly provided me with these samples,

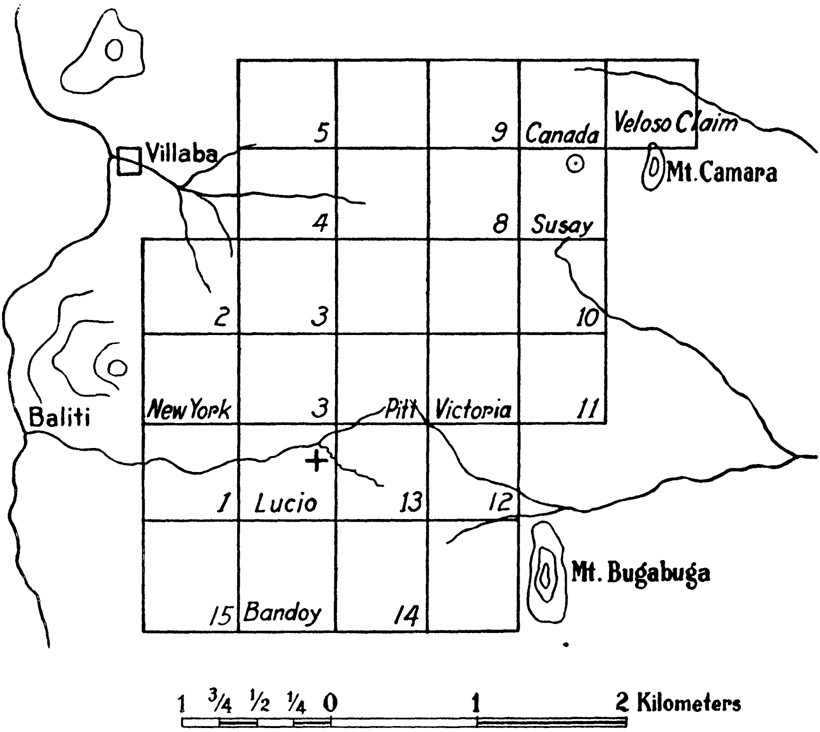

FIG. 2. Claim map, vicinity of Villaba.

This deposit is situated about 3 kilometers east of the small barrio of Baliti and about 5 kilometers south 30° E. from the municipality of Villaba on the west coast of the northwest peninsula of Leyte. The mine is on the south side of Baliti Creek near its head and a very excellent open face is exposed on the creek side for a distance of about 300 feet in an east-west direction. The bituminous strata have a dip of about 10 to 15 degrees in an easterly direction and rest upon typical clay shales of the Vigo group. * * * The bituminous strata are about 50 to 75 feet in thickness and are possibly traceable in a southern direction for 600 feet. These strata are essentially andesitic tuff. * * *.

The bituminous tuff at the Lucio mine is essentially a fault block. * * * Besides this large block * * * another small block is recorded by Mr. William Anderson, * * * as occurring a half mile to the north. The quantity of material in this large block has been variously estimated from a half million tons to as high as twenty million tons. The material

[3] In a personal communication dated September 20, 1922.

is mined by open-cut methods and taken to the beach on a small narrow-gauge railway. These two occurrences of rock asphalt near Baliti are the only ones known in this general region. Seepages of petroleum and leyteite occur a few miles north and northeast of Baliti. Pratt describes these other localities in detail in * * * Phil. Jour. Sci. 10, Sec. A. 1915.

The rock is dark brown, almost black. Its granular structure is easily perceivable with the naked eye. The grains are so thoroughly cemented that the rock is very hard to break in pieces, even with the aid of a knife or a hammer. Nevertheless, it can be crushed by means of the disintegrator and gives a slightly sticky powder. The impregnation is not quite homogeneous.

The chemical and physical examination of the rock must be preceded by an inquiry as to the possible industrial utilization of the material; the relative importance of the various tests is, of course, dependent on the uses to which the material is destined.

Two possibilities of commercial utilization of the bituminous rock must be considered: One is the separation of the bituminous substance from the admixture of worthless sand which it impregnates; the other is the utilization of the raw material, either in the form in which it occurs or amended by the introduction of more bitumen or sand.

The extraction of bitumen is impracticable from the point of view of treatment on a large scale. It would, of course, be possible to extract the bituminous substance, particularly its paraffin wax, by means of organic solvents such as, for instance, light petroleum ether; the expense, however, would be quite prohibitive, as a very considerable portion of the solvent would escape recovery. Boiling water is sometimes used in Europe as a means of separating the bitumen in bituminous sand; this treatment is founded on the principle that bitumens melt below the temperature of boiling water and, as they are lighter than water, they will float on the top of the liquid, while the sand, being relatively heavy, will settle at the bottom. This treatment does not succeed with the Leyte impregnated rock, as it is mainly composed of carbonated lime, and bitumen is known to adhere to calcium carbonate with an incomparably greater tenacity than it does to silica when boiled with water. Dry distillation is impracticable on account of the low percentage of bitumen in the rock, which would necessitate the use of stills of very large size for the recovery of relatively small amounts of distillate.

One method of separating the bitumen from the mineral matter deserves special mention. It is founded on the circumstance

that the impregnated mineral ingredient in our case consists mainly of salts which give, with hydrochloric acid, soluble chlorides. A glance at the composition of the rock, freed from bitumen, will explain the reaction, see page 626. If at some time in the future muriatic acid is produced in the Philippine Islands, particularly if it is obtained as a by-product, its use in the treatment of Leyte bituminous rocks will become very advantageous for the recovery of bitumen for road building and other purposes. Treatment with hydrochloric acid would reduce the freight and the cost of transportation of the bitumen; it would also adapt the bituminous substance, free from most of its inorganic impurities, to various uses for which the crude rock is not fitted.

Since no method of extracting the bitumen, wholly or partially, can be utilized industrially, Leyte bituminous rock can only be used for road surfacing. It therefore requires tests as to its adaptability for this particular purpose only.

As a matter of fact, the rock we are considering is already successfully used for road building. Mr. G. M. Veloso, treasurer of the Leyte Asphalt and Mineral Oil Company, Cebu, states that the above-named company—

> shipped a total of about 2500 tons of asphalt rock from their quarry which is located about 3 kilometers east of Baliti. Of this amount 1000 tons were shipped to Japan and the 1500 tons remaining were used for street paving in Manila, Cebu and Zamboanga. At present [September 19, 1922] the Asphalt Company has about 3,800 tons of asphaltic rock on the beach at Baliti ready for shipment to Japan.

In Japan, the material is used for road building.

Bituminous compounds used for paving consist of two components: The mineral aggregate which is the resisting ingredient and the bitumen which acts as a cement for the mineral aggregate. The resistance of the pavement to the wear of traffic is entirely dependent upon the mineral aggregate, but the coherency of the latter requires the presence of bitumen in proper amounts and of proper quality. This being the case, it is clear that, in order to determine the adaptability of our rock for use as a paving material and to be able eventually to remedy its defects and improve upon the material, it is important to examine qualitatively and quantitatively its two constituents.

For this purpose, samples of the rock were first separated into bitumen, which was completely extracted by the use of solvents such as benzene and carbon disulphide, and the mineral matter. The penetration of the rock not being homogeneous, the results

were variable. One sample (A) of 25.4230 grams gave the following results:

Constituent.	Quantity.	
	g.	*Per cent.*
Moisture and volatile matter	0.5756	2.26
Bitumen	2.0640	8.1
Mineral matter	22.7834	89.6
Total	25.4230	99.96

The volatile matter here consisted of liquid hydrocarbons which are volatile at temperatures around 100°, particularly in the presence of water. Without volatilization the bitumen content would be in the neighborhood of 10 per cent.

A large sample of rock (B) weighing 273.5 grams was attacked with hot dilute muriatic acid and extracted with benzene. After volatilization of the solvent by prolonged heating at 100° C., the extracted bitumen weighed 30.12 grams, or 11 per cent of the crude rock.

The bitumens of the two samples were treated separately with boiling ethyl acetate for the purpose of separating the paraffinaceous ingredient, which is soluble, from the insoluble tarry asphalt. The results were as follows:

Soluble and insoluble ethyl acetate in Samples A and B.

Sample—	Ethyl acetate.		
	Soluble.	Insoluble.	
	g.	*g.*	*Per cent.*
A	1.4710	0.5930	28.73
B	25.4131	6.7069	22.28

The bitumen of the impregnated rock is thus found to be considerably richer in asphaltic constituent than is Leyte pure bitumen. Pratt's[4] supposition that Leyte bitumens are derived from evaporation of paraffinaceous petroleum is evidently incorrect, since paraffin-base petroleums could never have left residues so rich in ethyl acetate insoluble as are Leyte bituminous rocks.

The physical characteristics of the rock bitumen are totally different from those of the pure bitumen. The rock bitumen is extremely sticky and has the appearance of a heavy maltha of viscous and semifluid consistency. Neither the penetration test nor the ductility test can be made on such a substance. The fixed

[4] Pratt, W. E., Philip. Journ. Sci. § A 10 (1915) 241.

carbon is 11.04 per cent. The stickiness and the viscosity of the rock bitumen is entirely due to the ethyl acetate soluble (paraffins) which, when extracted, was found to possess these characteristics, while the ethyl acetate insoluble (asphalt) was in all respects similar to the ethyl acetate insoluble of Leyte pure bitumen.

This difference between the paraffinaceous constituents of Leyte pure bitumen and of Leyte bituminous rock could be expected since mineral aggregate mixed with bitumen prevents to a certain extent any evaporation from the bitumen. Originally, as may be supposed, both varieties of bitumen were very similar, except perhaps in the content of the asphaltic ingredient, which may or may not have been increased in the rock bitumen at the expense of the paraffinaceous portion by the catalytic action of the mineral aggregate. At present, the rock bitumen differs from the pure bitumen by the presence of relatively volatile paraffin hydrocarbons, some of which are liquid and others semifluid. This difference apparently illustrates the relative stability to the action of atmospheric agents conferred upon bitumens by the admixture of mineral matter.

Natural asphaltic rocks seldom contain a sufficient quantity of bitumen to make them suitable for use as a paving material. In most cases bituminous fluxes have to be introduced to supplement this deficiency. Mastics containing as much as 15 and 20 per cent of bitumen are used in countries of temparate climate; but in tropical countries a much smaller percentage of bitumen is required. On the other hand, the amount of bitumen must also be regulated to the amount and character of the traffic. Pavements subjected to light traffic will require less rock than those destined to support heavy traffic. The properties of the flux to be mixed with our Leyte rock, if fluxing is found advisable, must be carefully considered, as it is a well-known fact that the cementing properties of bitumen fluxes depend greatly on their composition which should be largely asphaltic. As our Leyte bitumen is largely paraffinaceous, the use of fluxes derived from asphalt-base petroleum, such as the Trinidad epure or heavy residues of distillation of asphaltic oils, is advisable.

The examination of the mineral aggregate which is penetrated with bitumen has considerable importance in the road-building industry, in as much as the quality and the characteristics of the road surface are mainly dependent on the character of the sand which is cemented, and we have seen that this sand

cannot be separated economically from our bituminous rock and another sand substituted for it. The study of mineral aggregates used in road building requires an examination of fineness of grain and the determination of chemical composition.

The mineral matter impregnated with bitumen in our case consisted of loose white grains which were held together because of the cementing bitumen and which crumbled to powder when the bitumen was extracted with solvents. The size of the grains was determined by Mr. A. E. W. King, of the Bureau of Science. The sand sieved as follows:

	Per cent.
Passing 200-mesh sieve	16.95
Passing 100-mesh sieve	12.13
Passing 80-mesh sieve	4.33
Passing 50-mesh sieve	18.02
Passing 40-mesh sieve	8.77
Passing 30-mesh sieve	17.92
Passing 20-mesh sieve	18.46
Passing 10-mesh sieve	2.73
Retained on the 10-mesh sieve	0.14
	99.29

The size of grains desirable in asphaltic pavements depends on the character of the traffic that the pavement is destined to bear. Very fine grains permit the obtaining of closely bound and smooth asphaltic surfaces, but the pavement thus obtained cannot withstand heavy traffic so well as can a pavement made of coarse sand. On the other hand, pavements made of coarse sand must contain a high percentage of bitumen, as otherwise they are likely to crack easily. In general, moderately sized grains, such as those of our samples, are preferable for all purposes. They have a sufficient content of coarse grains and an appropriate amount of fine particles to fill the voids between the coarse grains.

The chemical composition of our mineral aggregate, as determined by Mr. E. Gutierrez, of the Bureau of Science, was found to be as follows:

	Per cent.
Water	0.48
Silica (SiO_2)	7.48
Iron oxide (Fe_2O_3)	0.96
Aluminum oxide (Al_2O_3)	4.58
Calcium oxide	47.44
Magnesia (MgO)	1.82
Combined CO_2	37.20
Total	99.96

The above table shows that the mineral aggregate is essentially composed of calcium carbonate. The Leyte impregnated rock is thus found to be a bituminous limestone, and it remains to see what kind of pavement can be made of this material as compared with the pavements made from bituminous sandstone.

It is a well-known fact that in the United States roads are made of artificial mixtures of bitumen, silicious sand, and limestone, whereas in Europe natural bituminous limestones are used. The latter are principally obtained from deposits at Val-de-Travers, Switzerland; at Seyssel, France; at Ragusa, Sicily; and at Limmer and at Vorwohle in Germany. The bituminous content of these natural rocks averages 10 per cent, and the material is mostly used without the addition of fluxes or fillers by merely heating it and spreading the softened mass on an appropriate foundation. The roads thus obtained in Europe are of excellent quality.

According to A. Danby [5] experiments were carried out by Messrs. Durand-Clay and Debray to determine the resistance to crushing stress of artificially made bituminous limestone and bituminous sandstone. He states:

> Blocks of equal sizes were made of the two materials, and though that comprised of the bituminous limestone broke under an average pressure of 328 kgs. per square centimeter, that made with the bituminous sandstone only resisted up to a pressure of 217 kgs. per square centimeter.

These experiments show that bituminous limestone is considerably more resistant to traffic than bituminous sandstone and that we therefore have a very important point in favor of the Leyte rock.

When we come, however, to consider the action of atmospheric erosive agents on pavements, we find that calcarious pavements weather out a great deal more rapidly than do those made of bituminous sandstone. The reason is that rain water always carries a non-negligible proportion of carbonic acid; this reacts with calcium carbonate forming calcium bicarbonate which dissolves in water leaving behind the bituminous cement, and the latter, deprived of a portion of its mineral aggregate, softens and becomes inutilizable for traffic. This action of rain water is fortunately slow; but in a rainy country, like the Philippines, the damage resulting to the pavement is not inconsiderable. This condition could be remedied by the introduction of a certain proportion of silicious fillers.

[5] Natural Rock Asphalts and Bitumen. London (1913) 160.

In conclusion, we find in Leyte bituminous rock an excellent natural paving material from local sources which fortunately exists in quantities sufficient not only to satisfy local needs but also for exportation. Slight defects of this material could be remedied, as we have seen, by the introduction of proper fillers and fluxes, according to requirements.

SUMMARY

The natural solid bitumens occurring in Leyte Province have been classed as "pure bitumen" and bitumen-impregnated rock, and have been studied from a chemical and physical standpoint showing:

1. That Leyte pure bitumen differs from other mineralogical deposits of bitumens, such as ozocerite, montan wax, hatchettite, and scheererite, but is related to ozocerite. It is suggested that the pure bitumen of Leyte be termed leyteite.
2. That the chemical and physical properties of the bitumen found in the impregnated rock differ from those of the pure bitumen.
3. That the mineral aggregate of the bitumen-impregnated rock is principally limestone.
4. That the bitumen-impregnated rock would be suitable paving material, both in its natural state and after the introduction of fillers and fluxes.

ILLUSTRATIONS

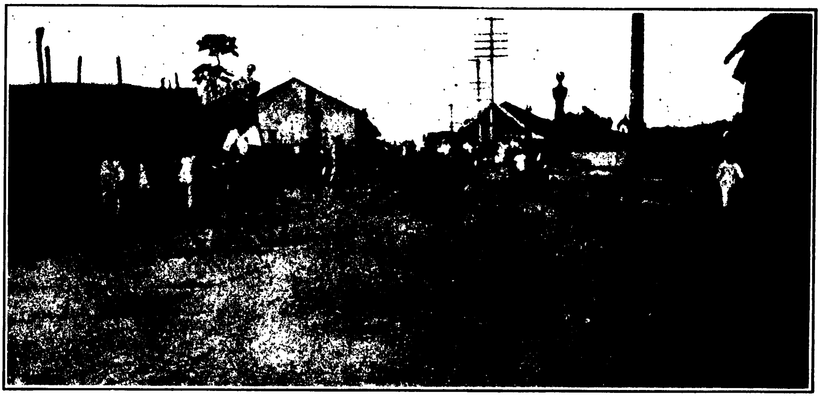

Fig. 1. A street in Cebu paved with Leyte asphalt.

Fig. 2. A street in Cebu paved with Leyte asphalt.

PLATE 1.

Fig. 1. Rock on the beach at Baliti.

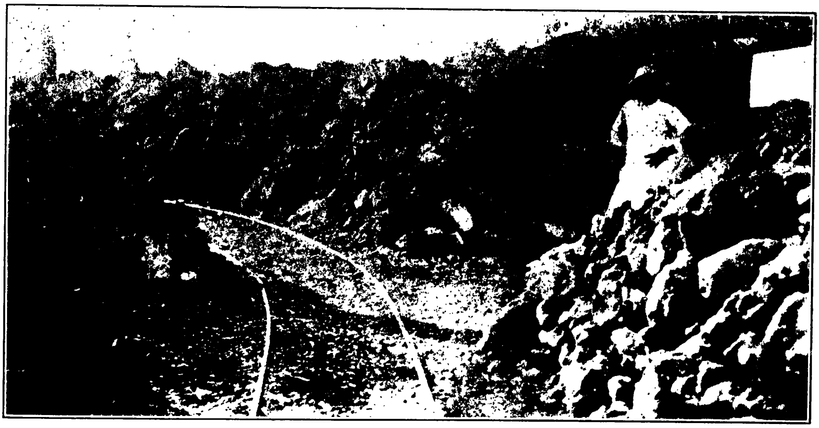

Fig. 2. Rock alongside the narrow-gauge railroad, Baliti.

Fig. 3. Laborers working, Lucio asphalt mine.

PLATE 2.

HEXAMETHYLENETETRAMINE AS A REAGENT IN MICROSCOPIC QUALITATIVE CHEMICAL ANALYSIS[1]

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TWO PLATES

Hexamethylenetetramine (hereinafter referred to as hmt) forms crystalline compounds with many inorganic salts. Some of these compounds are quite insoluble. They are generally of the additive type and hence any attempt to utilize hmt as a reagent in qualitative analysis must take into consideration the negative as well as the positive ion of the compound to be analyzed. In microchemical qualitative analysis, it has been found possible to obtain characteristic crystalline precipitates with hmt for certain of the positive ions in any of their combinations by performing the test in hydrochloric acid solution. Vivario and Wagenaar[2] state that characteristic insoluble crystalline compounds are formed with salts of platinum, iridium, palladium, osmium, silver, mercury, antimony, bismuth, tin and, in the presence of potassium iodide, with magnesium. Denigès,[3] in 1919, suggested that hmt might be used for the detection of bismuth in any of its combinations. I have found that hmt may be used for microchemical detection of other elements besides those above mentioned.

The present paper gives the result of thousands of microchemical tests made with hmt on inorganic compounds to determine all the elements giving characteristic crystalline compounds with this reagent; also the elements giving characteristic crystalline compounds with hmt and potassium iodide. The best method of applying the tests and their sensitivities have also been determined.

[1] Received for publication September 8, 1922.

[2] Pharm. Weekblad 54 (1917) 157. Unfortunately the original article was not available to me, but there is an excellent abstract in Chem. Abs. 11 (1917) 1385.

[3] Schweiz. Apoth. Ztg. 57 (1919) 497. Abstracted in Chem. Abs. 13 (1919) 2830.

EXPERIMENTAL

Salts of aluminium, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, cesium, cerium, chromium, cobalt, copper, gold, iridium, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, osmium, palladium, platinum, potassium, rubidium, selenium, silver, sodium, strontium, tellurium, thallium, thorium, tin, titanium, tungsten, uranium, vanadium, and zinc were tested with hmt in neutral and acid solution and with hmt plus potassium iodide in neutral and acid solution.

It was found that solutions of salts of antimony, bismuth, cadmium, gold, iridium, mercury, palladium, platinum, silver, and tin gave characteristic crystalline precipitates with hmt in solutions acidified with hydrochloric acid (silver is used in nitric acid solution). Salts of calcium, ferrous iron, magnesium, manganese, and titanium sometimes give crystalline compounds with hmt, but the crystals formed are not especially characteristic.

When a fragment of potassium iodide is added to a drop of a solution of hmt and a salt of antimony, bismuth, cadmium, palladium, platinum, or tin, characteristic crystalline compounds result. Calcium, iron, magnesium, and manganese [4] salts yield crystals which cannot be easily differentiated one from another. Free hydrochloric, sulphuric or nitric acid gives crystals with hmt and potassium iodide, but these crystals are easily distinguished from those formed with any of the above-mentioned metals (Plate 2, fig. 12).

Technic.—Of the various general methods of making microchemical tests,[5] the most satisfactory procedure proved to be that in which a fragment of the solid reagent is added to a drop of the solution of the substance to be tested. This drop should be from 2 to 4 millimeters in diameter. The preparation on the slide is then examined under a low-power microscope. Dilute solutions yield more nearly perfect crystals than concentrated ones. Scratching the drop with a small glass rod or platinum spatula is sometimes advantageous.

[4] Other metallic salts, such as those of arsenic, cobalt, lead, nickel, osmium, strontium, tellurium, and zinc yield crystalline compounds with hmt and with hmt and potassium iodide, but these compounds, being very soluble, will not interfere.

[5] Chamot, E. M., Elementary Chemical Microscopy, 1st ed. (1916) 251–259.

The sensitivity was determined by making the test on solutions of decreasing concentration until one was reached which gave no crystals. The concentration was figured in terms of the positive ion; that is, a 1 : 1,000 solution of silver nitrate contained 0.1574 g. $\left(\frac{AgNO_3}{Ag}\right)$ silver nitrate. The most dilute solution which gave crystals within about three minutes was taken as the limit of sensitivity.

TESTS WITH HEXAMETHYLENETETRAMINE

ANTIMONY

Sensitivity with hmt, 1 : 1,500.
Sensitivity with hmt + KI, 1 : 15,000.

When a fragment of hmt is added to a drop of a hydrochloric acid solution of an antimony salt, colorless octahedra and dodecahedra first appear. Toward the periphery of the drop square-ended prisms exhibiting parallel extinction then appear, gradually entirely replacing the crystals belonging to the isometric system. The latter seem to be unstable or soluble in excess of the reagent.

If no crystals appear, a fragment of potassium iodide is added to the test drop. Yellow octahedra are formed in the presence of antimony. Bismuth and tin also yield yellow octahedra, but the crystals are much smaller. The test should be performed in a solution acidified with hydrochloric acid. Nitric and sulphuric acids do not interfere. However, any one of these three acids will give colorless crystals in the presence of hmt and potassium iodide; the crystals are more soluble than the yellow octahedra formed with antimony, bismuth, or tin and, furthermore, are easily distinguished by form and color and by the fact that they exhibit parallel extinction under crossed nicols (Plate 1, fig. 1, and Plate 2, fig. 12).

BISMUTH

Sensitivity with hmt, 1 : 8,000.
Sensitivity with hmt + KI, 1 : 100,000.

Hexamethylenetetramine forms with bismuth compounds in hydrochloric acid solution large, colorless, highly refractive octahedra and dodecahedra belonging to the isometric system. Bismuth never gives crystals which polarize and may thus be distinguished from antimony (Plate 1, fig. 2).

When a fragment of potassium iodide is added to the test drop containing the bismuth salt and hmt there is immediately produced an amorphous yellow precipitate which gradually changes into tiny, yellow octahedra. This is an exceedingly delicate test for bismuth. See precautions noted under antimony.

Bismuth may be readily distinguished from tin by adding to a test drop a fragment of cesium chloride and then a fragment of potassium iodide. Bismuth yields orange-red hexagonal plates, while tin yields yellow octahedra.

Denigès [6] states that the compound of bismuth and hexamethylenetetramine has the formula

$$3(C_6H_{12}N_4.HCl).BiCl_3$$

According to Ley [7] the iodide compound may have one of the three forms

$$3(C_6H_{12}N_4.HI)BiI_3,\ 2(C_6H_{12}N_4.HI)BiI_3,\ \text{or}\ C_6H_{12}N_4.HI.BiI_3.$$

TIN

Sensitivity with hmt, 1 : 1,000.
Sensitivity with hmt + KI, 1 : 1,000.

In strong hydrochloric acid hmt forms with solutions of tin colorless octahedra (an amorphous precipitate is obtained in solutions which are neutral or only slightly acidified). The crystals are usually smaller than those formed with bismuth and the test is not so delicate.

The addition of potassium iodide gives rise to exceedingly tiny yellow octahedra gradually crystallizing from a yellow amorphous precipitate. See precautions under antimony.

CADMIUM

Sensitivity with hmt, 1 : 200.
Sensitivity with hmt + KI, 1 : 2,200.

Concentrated hydrochloric acid solutions of cadmium salts give with hmt thin, colorless plates belonging to the hexagonal system.

If potassium iodide is added to the test drop, highly refractive, square-ended, colorless prisms and hexagonal plates appear (Plate 2, fig. 9). These crystals belong to the hexagonal system and are very characteristic. See precautions under antimony.

[6] Loc. cit.

[7] Annalen **278** (1894) 57.

According to Ray and Sarker,[8] the cadmium iodide-hexamethylenetetramine compound may have the formula

$$2(CdI_2).2(HI)3(C_6H_{12}N_4) \text{ or } 2(CdI_2)2(C_6H_{12}N_4).$$

The following metals are grouped together because of the similarity of the crystals formed with hmt and with hmt + KI:

	Sensitivity with hmt.	Sensitivity with hmt + KI.
Calcium	1 : 200	1 : 1,000
Iron (Fe'')	1 : 1,000	1 : 1,000
Magnesium	1 : 100	1 : 1,000
Manganese (Mn'')	1 : 1,000	1 : 2,000

In hydrochloric acid solution they all yield triclinic, four- or six-sided plates with hmt. A similar type of crystal is given when potassium iodide is added (Plate 2, figs. 10 and 11). In all cases, the crystals form only around the melting fragment of hmt or potassium iodide.

GOLD

Sensitivity with hmt, 1 : 900.

Gold chloride solutions yield with hmt very characteristic pale yellow needles or thin plates showing strong polarization with parallel extinction. These needles form either a kind of grid at 60° angles or rosettes of plates or needles. There is sometimes a tendency to form long, curved, hairlike needles (Plate 1, fig. 3). Since the crystals are soluble in excess of reagent, care must be taken to use only a very tiny fragment of hexamethylenetetramine in the test drop. The compound[9] formed has the formula $C_6H_{12}N_4 . AuCl_3$.

Mercury and silver interfere with the test for gold. The presence of palladium tends to make the gold come out as moss-like crystals. Platinum, palladium, and iridium are readily distinguished from gold by this test (Plate 1, fig. 5).

IRIDIUM

Sensitivity with hmt, 1 : 2,000.

Iridium salts yield with hmt highly characteristic tiny red-brown octahedra or crosses belonging to the isometric system. A large excess of reagent should be avoided. The crystals usually appear after a few minutes near the periphery of the drop and grow larger on standing.

[8] Trans. Journ. Chem. Soc. **119** (1921) 390.
[9] Moschatos und Tollens, Annalen **272** (1893) 277.

Palladium and gold do not interfere with the test for iridium. Platinum tends to make the red-brown octahedra a lighter shade. Silver and mercury interfere.

PLATINUM

Sensitivity with hmt, 1 : 5,000.

Platinum salts yield highly refractive pale yellow octahedra with hmt. As the platinum solution becomes more dilute the crystals formed when hmt is added become smaller. As the small crystals are almost colorless care must be taken not to confuse these with the colorless octahedra formed with hmt and bismuth or tin compounds. The platinum crystals, however, turn dark reddish brown upon the addition of a tiny fragment of potassium iodide.

The platinum-hexamethylenetetramine compound[10] has the formula $2(C_6H_{12}N_4 \, . \, HCl)PtCl_4+4H_2O$.

In the presence of iridium the platinum crystals are darkened somewhat, so that they have a color between the yellow of the platinum salt and the red-brown of the iridium salt.

In mixtures of platinum and palladium, the former usually comes out first, the latter on standing or by scratching. The two are readily distinguished under crossed nicols as the palladium crystals alone exhibit extinction. Large amounts of silver or mercury interfere with the test for platinum.

PALLADIUM

Sensitivity with hmt, 1 : 8,000.

Palladous salts yield with hmt characteristic, very thin, colorless plates strongly polarized under crossed nicols. The crystals tend to grow large if the drop is left undisturbed, but give small, thin crystals if the preparation is scratched (Plate 1, fig. 6). An excess of hmt is necessary. The crystals form around the melting fragment of hmt. When a tiny fragment of potassium iodide is added the crystals are colored a dark brown.

Mercury interferes with the test for palladium. See remarks under platinum.

MERCURY

Sensitivity with hmt, 1 : 1,000.

Mercuric salts form with hmt in neutral solution colorless, square-ended, slender prisms belonging to the monoclinic system (see Plate 2, fig. 8). The crystals often form rosettes of needles.

[10] Tollens, B., Ber. d. deut. Chem. Ges. 17 (1884) 655.

In concentrated solution they are usually feathery, appearing black by transmitted light and white by reflected light. In hydrochloric acid solution there are formed colorless plates and needles.

When free hydrochloric acid is absent the compound[11] has the formula $C_6H_{12}N_4.2HgCl_2+H_2O$. When hydrochloric acid is present the compound formed is $C_6H_{12}N_4.HCl.2HgCl_2+H_2O$.

SILVER

Sensitivity with hmt, 1 : 200.

Silver salts in nitric acid solution form with hmt colorless needles or plates belonging to the monoclinic system. The plates usually appear only when the preparation is scratched. They often show high polarization colors (Plate 2, fig. 7).

Palladium may interfere with the test for silver.

SUMMARY

Hexamethylenetetramine can be used as a reagent in microscopic qualitative chemical analysis for the identification of salts of antimony, bismuth, tin, cadmium, gold, iridium, platinum, palladium, mercury, and silver. It can also be used as a group test for calcium, magnesium, iron, and manganese. The crystal forms and the best method of applying the test have been described. The sensitivities of the various tests have been determined.

[11] Delépine, Compt rend. des Acad. sci. 120 (1895) 744. Schmiz, E., Ber. Pharm. Ges. 20 (1910) 201, gives the formula $C_6H_{12}N_4.2HgCl_2$.

ILLUSTRATIONS

[Magnification × 50.]

PLATE 1

FIG. 1. Crystals of antimony salt with hexamethylenetetramine in hydrochloric acid solution.
2. Crystals of bismuth salt with hexamethylenetetramine in hydrochloric acid solution.
3. Crystals of gold chloride with hexamethylenetetramine.
4. Crystals of platinum chloride with hexamethylenetetramine.
5. Crystals of the gold salt (fig. 3) and the platinum salt (fig. 4) formed with hexamethylenetetramine in a solution of gold and platinum.
6. Crystals of palladous chloride with hexamethylenetetramine.

PLATE 2

FIG. 7. Crystals of silver nitrate with hexamethylenetetramine.
8. Crystals of mercuric salts with hexamethylenetetramine in hydrochloric acid solution.
9. Crystals of cadmium salt with hexamethylenetetramine and potassium iodide in hydrochloric acid solution.
10. Crystals of magnesium salt with hexamethylenetetramine and potassium iodide in hydrochloric acid solution.
11. Crystals of manganous salt with hexamethylenetetramine in hydrochloric acid solution.
12. Crystals formed from a mixture of hydrochloric acid, potassium iodide, and hexamethylenetetramine.

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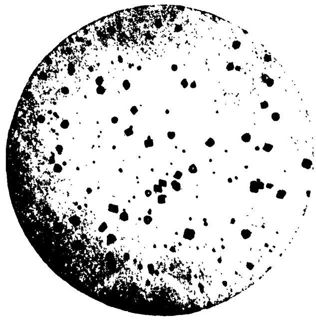

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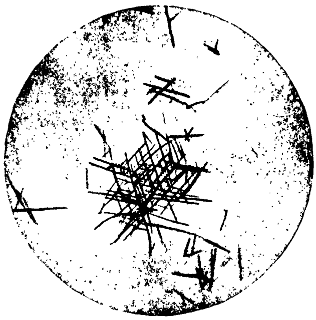

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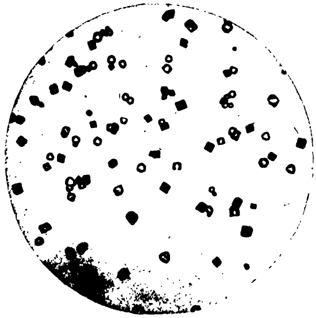

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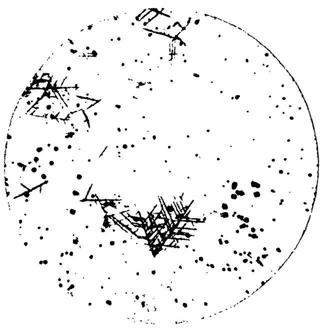

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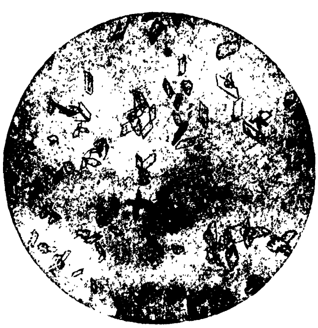

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PLATE 1.

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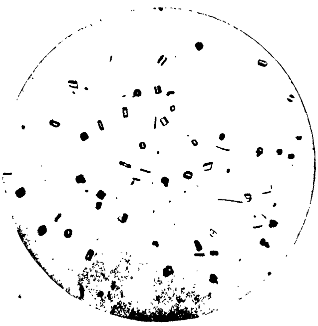

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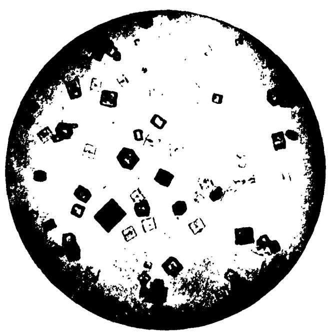

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PLATE 2.

ERRATA

VOLUME 21, NO. 3

Page 324, line 16, *for* Scutellum with three pits *read* Scutellum with two pits.

Page 324, line 22, *for* **Oberthürella** Kieffer *read* **Oberthürella** Saussure.

Page 324, in key to the Liopterinæ, as a footnote from **Allocynips**, *add:*

Mayrella Hedicke (1922) instead of forming a new subfamily seems to be close to *Allocynips* and separated from it by the 12- instead of 13-segmented antennæ of the female.

Page 325, line 1, *for* Malar space one-third eye. *read* Malar space as long as eye.

Page 325, line 4, *for* Malar space as long as eye. *read* Malar space one-third of eye.

Page 326, line 8, *for* Interocular space 0.56 eye. *read* Interocular space 0.56 transfacial and area 1.1 times as broad as high. Malar space 0.56 eye.

Page 331, line 18, *for* 42.25 *read* 42 : 25.

ADDENDUM TO VOLUME 22

On page 80, after paragraph 5, insert the following:

6. The pigs refused to take the raw shredded coconut meat, so that the raw shredded meat was pressed and 10 cubic centimeters of the undiluted juice therefrom was fed through a tube each day. This juice contains very little vitamine since it did not lengthen the life of the pigs appreciably.

7. Ten cubic centimeters of juice expressed from the raw banana-flower bud did not lengthen the span of life.

8. Twenty-five grams of raw Chinese persimmon given daily protected the pigs for periods of from seven to sixteen weeks.

9. Thirty grams of raw Chinese persimmon given daily protected two pigs from scurvy for a period of twenty-four weeks and, therefore, this seems to be the minimum amount for complete protection. Pigs 11P and 12P were taken off this diet after the fourteenth week, since we needed them for other purposes.

INDEX

[New generic and specific names and new combinations are printed in **clarendon**; synonyms and names of species incidentally mentioned in the text are printed in *italic*.]

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